

|the |art |of |maya
PERSONAL LEARNING EDITION

Alias | Learning Tools

|the |art |of |maya™

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|the |art |of |maya
PERSONAL LEARNING EDITION

 Alias | Learning Tools

Welcome to The Art of Maya - Personal Learning Edition. This virtual book will help guide you through the fundamental concepts of 3D space, and animation in the context of Maya. This tool will help you understand the hows and whys of computer graphics. It takes many examples and samples from our retail book, The Art of Maya. The Art of Maya - Personal Learning Edition will help you understand many of the theories you'll explore through the on-line tutorials included with Maya Personal Learning Edition. For deeper discussions, additional images, and more advanced concepts, purchase The Art of Maya from our online store at www.alias.com.

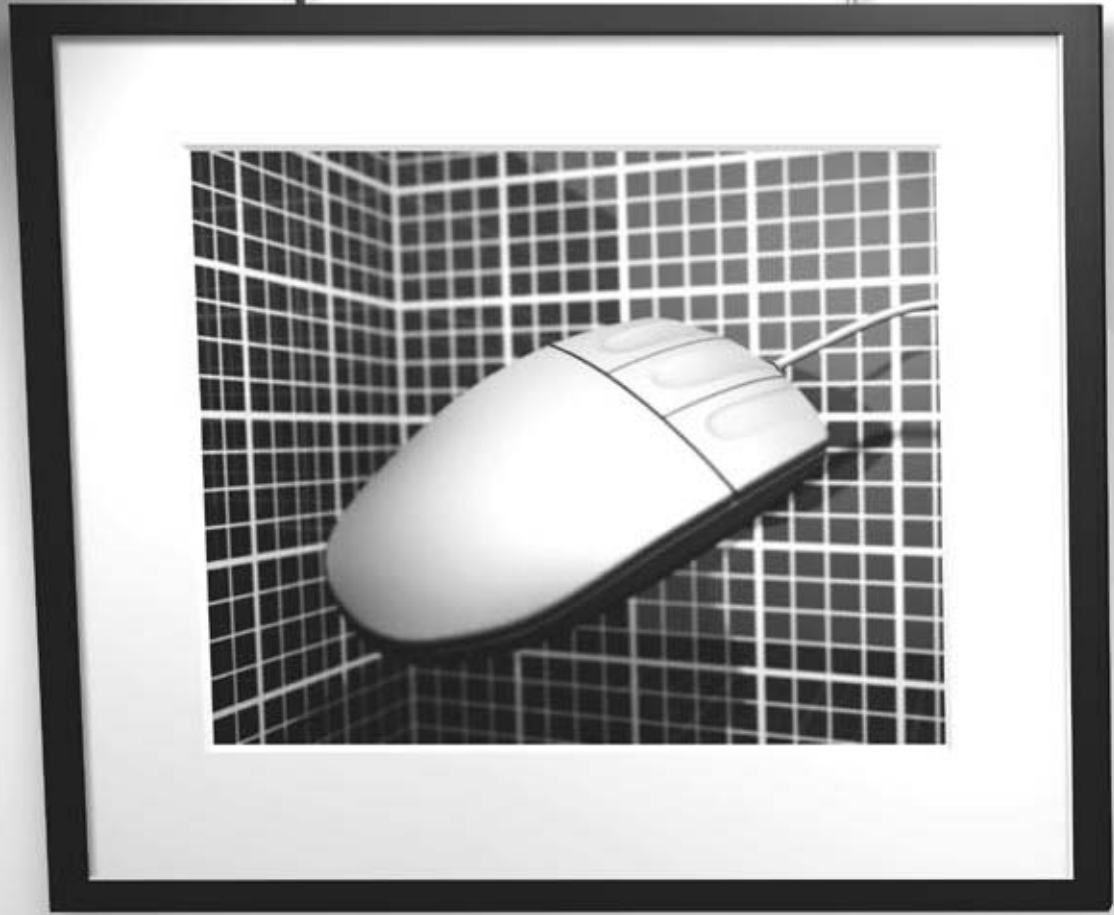
Three-dimensional computer animation is visible all around us. From new and exciting worlds created for movies to interactive video games with rich textured environments, the impact of 3D artwork is impossible to ignore. Because the computer is involved, there has always been an emphasis on the technical aspects of creating this imagery. However, the people using this software, more often than not, come from a creative background in one of the visual arts. They recognize the benefits of learning this new media and are willing to acquire a deep knowledge of computers and 3D animation software to master their craft. The quality of the artwork they produce is incredible and all of us have enjoyed watching 3D computer animation's popularity grow.

Maya™ is a 3D computer software package that pushes the boundaries of what can be accomplished in the 3D animation field. It is an integrated package that mixes modeling, animating, texturing, dynamics, lighting, and rendering tools in one consistent User Interface. Of course, the depth offered by Maya's tool set can be daunting to new users and even to 3D artists who have, over the years, specialized in only one of the many disciplines involved in the animation process. With Maya, the possibilities seem almost endless.

This book is your guide to these possibilities. It is designed to provide a visual look at the various concepts that go into the production of animations and interactive 3D media. While not all the possible tools and/or workflows are explored, the book will give you an in-depth look at what Maya can do. You will learn which tools will help you achieve your goals and why these tools work the way they do. In some cases, Maya's approach to calculating an effect, such as lighting, is compared to a real-world approach with which many artists have previous experience. By learning how these two approaches are similar and how they differ, you will be able to transfer your skills to using Maya.

This book's main focus is on understanding. You can choose to read this book before you start working on the computer or you can get your feet wet first, then come back to get the big picture. Either way, this book is meant to be your companion as you explore the world of Maya and its use as a creative tool. In time, you will find your focus shifts from Maya's technical issues to your artwork. Understanding how Maya works will free your creativity and let you focus on producing impactful artwork and of course, cool effects.





|3d |computer |graphics

Animation is an art form created and cultivated over the last century. While drawing, painting, sculpting, and photography allow artists to represent shape and form at a single point in time, animation lets artists explore a world in motion.

Through animation, new worlds can be imagined. This modern art form evokes emotion through the movement of a sequence of drawings, paintings, photographs or rendered images.

The introduction of 3D computer graphics over the last couple of decades has had a big impact on the world of animation. Digital characters and sets can now be built and animated, then presented in different media formats such as film, video, and interactive games. Characters and visual effects can even be seamlessly integrated into live-action footage.

Maya is a 3D animation system that lets artists play the roles of director, actor, set designer, and cinematographer.



3D Computer Animation

```
setAttr "spotLight1.rotate" -type double3 0  
2.5698 ; setAttr  
"spotLight1.translate" -type double3 0  
65.764707 ; setAttr
```

3D Computer Animation

The world of 3D computer graphics has grown from experimental short films to full integration into the creative process for many types of media. From flying logos to digital actors, the field of 3D computer graphics has evolved rapidly over the last two decades. The use of 3D graphic tools is now an important part of many television, film, and multimedia projects.

What makes 3D such a useful tool is the way it simulates real objects. The way objects appear in perspective, the way a surface bends and twists, or the way a light illuminates a space – all of these complex 3D effects can now be recreated on the computer. The resulting digital images can then be integrated into other media types using familiar compositing and editing techniques.

Maya is a 3D animation system that addresses the needs of a wide variety of digital content creators. Maya's tools and techniques have been developed with the artist in mind, while command-based scripting offers ways to build customized tools that suit more integrated production workflows.

BROADCAST

There is a good chance that anyone involved in the early years of 3D computer graphics has had to animate a flying logo. This use of 3D offered a new and dynamic way of getting the message across – always important in the world of advertising. Since then, the use of 3D in broadcast has evolved and more sophisticated artwork is being produced.

Flying logos are now integrated into more complete 3D environments where a product is advertised or a corporate message introduced. Character animation is also used more to bring objects to life and help sell the message.

Maya has helped open the door to a more complex use of 3D in the broadcast world. With integrated modeling, animation, characters, visual effects and rendering, a smaller video production house can now easily add 3D into their existing 2D workflow.



CNN Headline News, © 2000 CNN.
Image courtesy of David Price

FEATURE FILMS

The last few years have seen a sharp rise in the use of 3D in feature films. While many films have integrated 3D into existing live action scenes, Pixar's *Toy Story*® became the first feature-length animation that used 3D exclusively for characters and sets. Recently Sony Pictures Imageworks' *Stuart Little*® took this one step further and made a digital mouse the star of a live-action movie. Digital creatures, characters and sets continue to show up in the movies and even traditional filmmakers are starting to consider 3D a standard part of the production process.



Feature films tend to use many computer programs to complete a project, including in-house software and off-the-shelf software such as Maya. Maya is most often used for modeling, animation, character animation, and dynamics simulations such as cloth. Maya's open architecture makes

it easy for Computer Graphics (CG) supervisors to build custom tools to help streamline production.

VISUALIZATION AND WEB

Digital content creation tools are used in a number of fields including fine arts, architecture, design, education, and scientific research.

Some of these fields require 3D computer graphics to produce highly realistic images for the evaluation of projects or prototypes. With advances in the web's ability to present graphic and 3D information, visualization on the internet is emerging as an important tool for many companies.

INTERACTIVE VIDEO GAMES

Over the years, video games have developed from black and white pixels to real-time virtual environments built with 3D characters and sets. The graphics used in these games have always conformed to the capabilities of the game console on which they are delivered. Tomorrow's next-generation game systems use the same kind of computing power as the workstations that you use today to run Maya. This is breaking down limitations of the past.

Game artwork is becoming more sophisticated with complex 3D models, texture maps, lighting, and even dynamics. Maya is an ideal tool for generating this kind of 3D artwork and includes tools to address the special needs required to build content for real time.



VISUAL EFFECTS

While CG actors star in movies of their own, 3D computer graphics is changing how visual effects are used for both film and television. Smaller productions can now afford to integrate 3D graphics into their work while large film productions can now achieve effects only dreamed of in the past.

Film sets can be partially built and then extended with detailed 3D digital sets. Also, animated stunt people can be thrown off buildings in ways not recommended for real people. And, smoke, fire, and exploding objects can now be simulated within the safety of a computer screen.

Maya's tools, especially Maya's Dynamics, are ideal for generating visual effects that can be fully integrated into live-action shots. The best effects make it impossible to find the line between reality and where computer graphics is used.



```
setAttr "spotLight1.rotate" -type double3 0  
2.5698 ; setAttr  
"spotLight1.translate" -type double3 0  
65.764707 ; setAttr
```

Technical Creativity

As an artist working in a new medium, you must first understand the technical aspects of your new tools before you can reach your full creative potential. Just as a painter must learn how a particular paint mixes and dries on canvas, and a photographer must learn what film speed works best with a particular lens, a 3D artist must learn the basics of setting keyframes, working with 3D geometry, and setting up materials and lights for photorealistic rendering.

To fully master computer animation, you must have a balance of artistic and technical skills. Not only must you learn how to work with shape, form, motion, color, and texture, but also you must learn how the computer interprets all of these elements. While Maya will allow you to go far without understanding all the technical details, you will have greater creative freedom with more knowledge.

GETTING TO KNOW YOUR COMPUTER

If you are sitting down at the computer for the first time, you may be intimidated by the many computer-based tasks you must learn such as opening applications, moving and saving files, and even how to work over a network. If you work in a larger production house, you probably have technical assistance on-site to help you get through this part of the learning process. In a smaller production house, you likely have less assistance and must learn more on your own. Luckily, these skills come quickly with experience. The best way to learn is to dive in and start working.

GETTING STARTED WITH MAYA

There are several steps to getting started with Maya. This book is designed to give you a conceptual understanding of how Maya works, while the *Learning Maya* tutorial book gives you project-based experience. You can also use the reference manuals and Web tutorials offered at the Alias Web site.

While these academic tools are important, they can't replace true production hands-on experience. One good way to begin using the software is to model, render, and animate a real object -- an object you can study, document and accurately turn into a digital scene. Try to build and animate your favorite old toy, a household appliance or even your own face.

By using a real object, you will be able to evaluate your success against the real object. By focusing on creating something you will be able to apply the knowledge you have gained from this process.

TRANSFERRING TRADITIONAL SKILLS

Artists with skills in traditional media will find the transition to 3D computer graphics easier once they get used to working on a computer. In fact, new 3D artists should take the time to learn one or more of the following traditional art forms because they can help enhance 3D skills:

DRAWING AND SKETCHING

Drawing is a technique of representing the real world by means of lines and shapes. This skill requires the ability to observe and record the three-dimensional world. This skill can also be used to create storyboards and character sketches, which are great tools for developing an idea before proceeding to computer graphics.

CEL ANIMATION

Cel animators create 2D art through motion. Cel animation includes traditional techniques such as squash and stretch, anticipation, overlapping action, and follow through. Many of these 2D techniques translate very well into 3D environments.

PAINTING

Painters learn to work with color, light, shape, form, and composition. On the computer, these skills help create texture maps, position lights, and compose scenes.

CINEMATOGRAPHY

Knowledge of traditional cinematography will help artists use real-world techniques when setting up CG lights and cameras. This skill is very important when working with 3D graphics that are integrated into live-action plates.



PHOTOGRAPHY

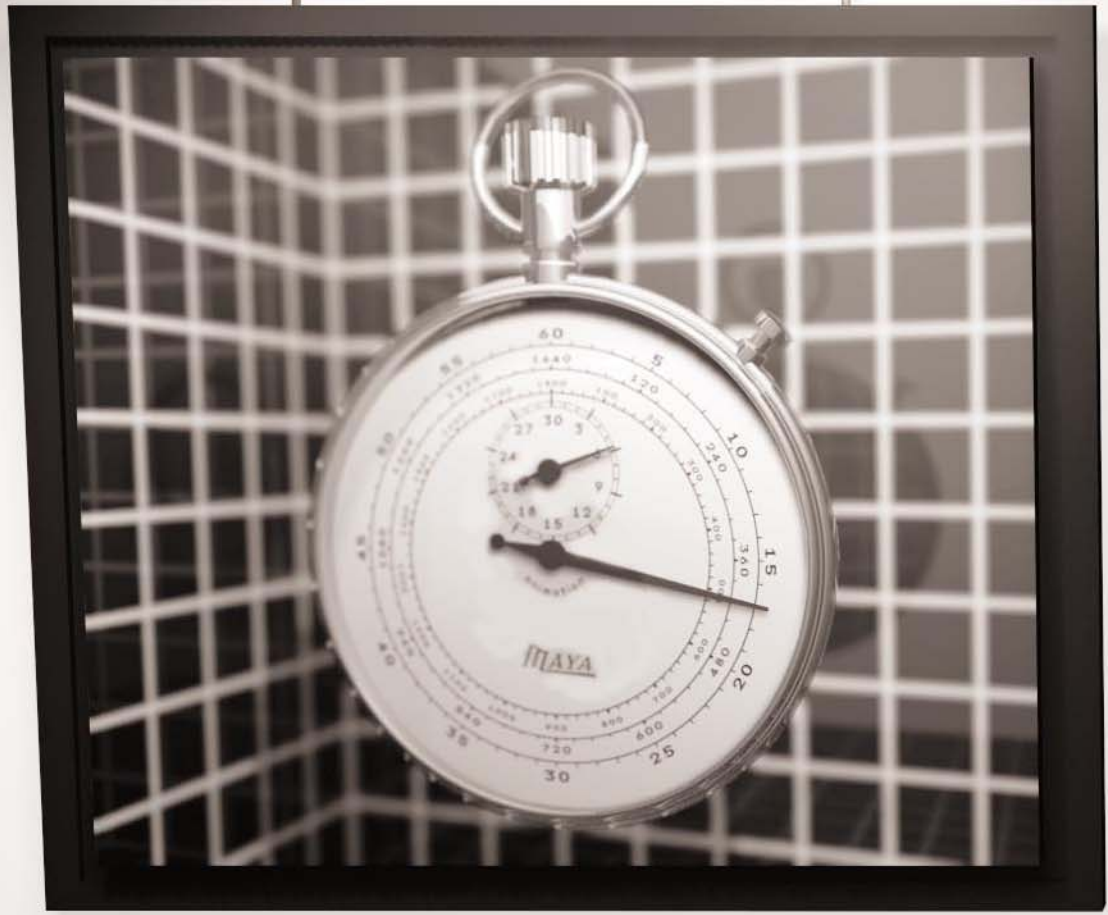
Still photography requires an understanding of lighting and camera effects such as key lights, focal length, and depth of field. Photography also teaches good composition techniques that are useful for framing scenes.

SCULPTURE

Sculpturing with clay, stone, and metal requires an intimate understanding of shape and form. Hands-on experience in shaping complex surfaces is a great asset when working with digital surfaces in Maya.

ARCHITECTURE

Architects often make good 3D artists because they are trained to think in plane, section, elevation, and perspective. Building models by hand is another skill they develop that makes it much easier to work in a digital environment.



| time | and | space

With 3D computer animation, artists work in a digital world where space, color, texture, time, shape, and form are tools for creating images and sequences of images.

All of these physical realities must be translated into a computer language based on numbers. In fact, Maya scenes and images are really just databases of numbers that are interpreted by Maya and presented on the computer screen in a more visual and artist-friendly manner.

While artists do not have to know how the numbers are interpreted by the computer, they do need to understand some of the ways in which space, color, and time are quantified and recorded. Learning how the computer interprets digital information such as 3D coordinates, frames per second, or the RGB information stored in a bitmap image can help artists understand how this information relates to their own perception of time and space.

```
setAttr "spotLight1.state" -type double3 0
2.56 0.98 ; setAttr
"spotLight1.position" -type double3 0
0.5 7.704707 ; setAttr
```



3D Space

Every day, you come into contact with three-dimensional objects and spaces. You have learned how to recognize and work with three dimensions in your daily routine and have an intuitive feel for how it works. If you have ever drawn a sketch, built a model or sculpted a model, you also have a creative feel for how shape and form can be described in 3D.

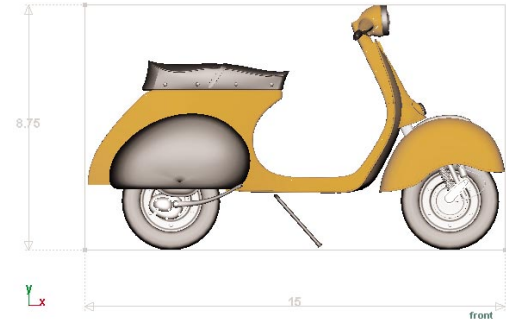
Three-dimensional objects can be measured and quantified. If you have ever measured the length, width, and height of an object, you have analyzed its three dimensions. You can also determine an object's position by measuring it in relation to another object or to a point in space.

In Maya, you can explore three-dimensional objects and recreate them on screen as rendered images complete with lights and shadows.

XYZ COORDINATE SPACE

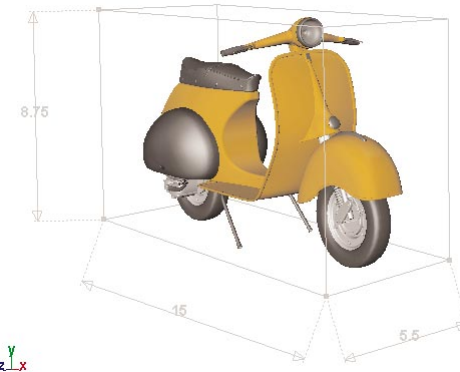
In Maya, 3D space is measured using three axes that are defined as the X-axis, the Y-axis, and the Z-axis. If you imagine looking into a movie screen, the width would be the X-axis, the height would be the Y-axis, and the depth would be the Z-axis. In Maya, these axes are presented with X and Z on the ground and Y as the height.

You can find any point in this 3D world by defining a coordinate for each of the axes. To help you visualize these coordinates, a grid with axis indicators shows you their orientation.



TWO DIMENSIONS

When you measure the width and height of an object, you are analyzing two of its dimensions. The X and Y axes can be used to find points on an object, such as the center of the wheel or the position of the headlight in this two-dimensional space.



THREE DIMENSIONS

When you measure the length, width, and height of an object, you must consider a third dimension as defined by the Z-axis when defining points in space.

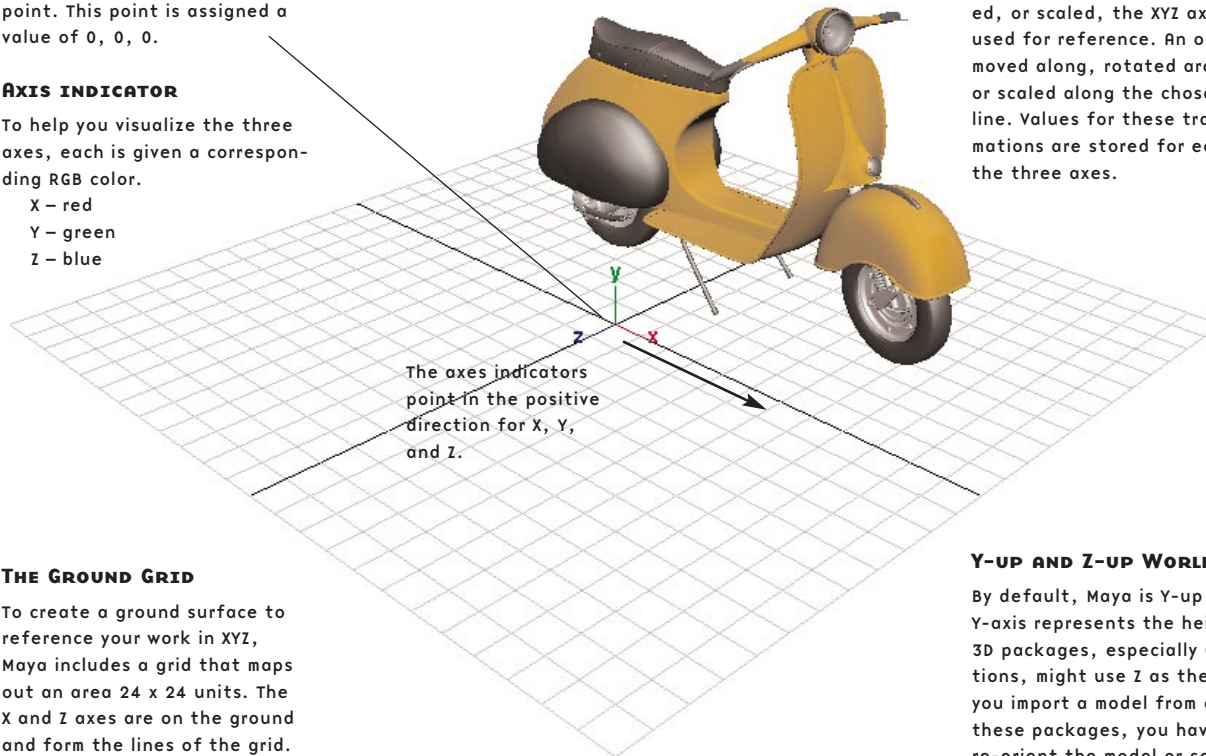
ORIGIN

Points in a 3D coordinate system are measured against an origin point. This point is assigned a value of 0, 0, 0.

AXIS INDICATOR

To help you visualize the three axes, each is given a corresponding RGB color.

- X – red
- Y – green
- Z – blue



The axes indicators point in the positive direction for X, Y, and Z.

TRANSFORMATIONS

When an object is moved, rotated, or scaled, the XYZ axes are used for reference. An object is moved along, rotated around, or scaled along the chosen axis line. Values for these transformations are stored for each of the three axes.

THE GROUND GRID

To create a ground surface to reference your work in XYZ, Maya includes a grid that maps out an area 24 x 24 units. The X and Z axes are on the ground and form the lines of the grid. The Y-axis is the height.

Y-UP AND Z-UP WORLDS

By default, Maya is Y-up where the Y-axis represents the height. Some 3D packages, especially CAD applications, might use Z as the height. If you import a model from one of these packages, you have to either re-orient the model or set up Maya as a Z-up world.



```
setAttr "stopWatchState" -type double3 0  
2.56098; setAttr  
"stopWatchTime" -type double3 0  
05.704707; setAttr
```

Time

In the world of 3D animation, time is the fourth dimension. An object will appear animated if it either moves, rotates, or changes shape from one point in time to another. Therefore, learning how time works is crucial to the animation process.

Both live action and animation use either film or video to capture motion. Both media formats use a series of still images that appear animated when played back as a sequence.

Film and video images are often referred to as **Frames** and most animation is measured using frames as the main unit of time. The relationship between these frames and real time differs depending on whether you are working with video, film or other digital media.

- Game (15 fps)
- Film (24 fps)
- PAL (25 fps)
- NTSC (30 fps)
- Show (48 fps)
- PAL Field (50 fps)
- NTSC Field (60 fps)
- milliseconds
- seconds
- minutes
- hours

FRAMES PER SECOND

Frames can be played back at different speeds that are measured in frames per second (fps). This is known as the **Frame rate** and it is used to set the timing of an animation. The frame rate is required to output animation to film or video, and to synchronize that animation with sound and live-action footage.

In Maya, you can set your **Frame rate** in the **Preferences** window. By default, Maya's frame rate is 24 fps. If you have a background in animation, confirm your time units to ensure you set keys properly.

Because seconds are the base unit of time, it is possible to set keys at 24 fps, then change your frame rate to 30 fps. This will scale the timing of your animation to match the timing as measured in seconds.



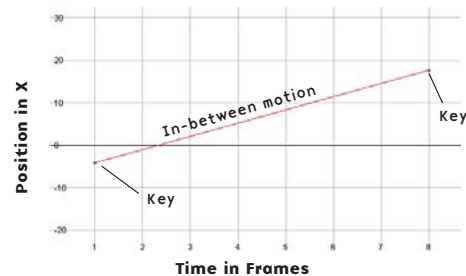
HOW OBJECTS ARE ANIMATED USING KEYFRAMES

Keyframe animation is created by capturing values for attributes such as translation or rotation at key points in time. An animation curve is then drawn between the keys that defines or interpolates where the object attribute would be at all the in-between frames.

Animation curves can be viewed as a graph where time is mapped to one axis and the animated attribute is mapped to the other. In Maya, virtually every attribute can be animated in this manner. The way in which you set keys and control the in-between motion determines the quality of an animation. As scenes become more complex, you will learn to create control attributes that can drive the motion of different parts of your scene to help simplify the process of setting keys.

MAPPING AGAINST TIME

Two keyframes are mapped against time, then an animation curve interpolates the motion between the keys. The shape of the curve determines the quality of the motion.

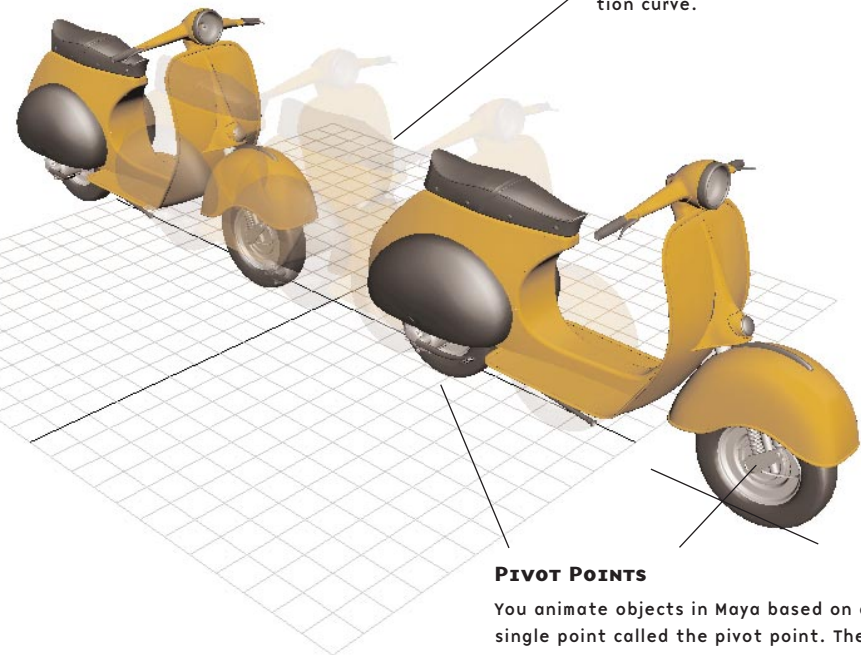


SETTING KEYS

When you know that your object or character needs to be at a certain place at a certain time, you set a key. With characters, you can create poses out of a number of keys set for different parts of the character.

IN-BETWEEN

The position of objects in between the two keyframes is determined by the shape of the animation curve.



PIVOT POINTS

You animate objects in Maya based on a single point called the pivot point. The pivot for the whole scooter would lie on the ground, while the pivot for a wheel would be at its center. The position of the pivot sets the center of the axes for rotating or scaling objects in your scene.

```
setAttr "spotLight1.state" -type double3 0
2.56098; setAttr
"spotLight1.radius" -type double3 0
05.704707; setAttr
```



Bitmap Space

A bitmap is a representation of an image, consisting of rows and columns of pixels, that is stored color information. Each pixel (picture element) contains a color value for a number of channels – red, green and blue. When you view these channels together, at a high enough resolution, all of the different colors form a complete image. These images can then be output to video, film, or printed on paper.

Bitmap images play a number of roles in an animation system such as Maya. When Maya renders a scene, the geometry, lights, and materials are calculated from the camera's point of view and a bitmap image or a series of images results. Further manipulation of the image in two dimensions is then possible using compositing or paint packages. Bitmap images are also used as texture maps to help add color and detail to the surfaces in scenes.

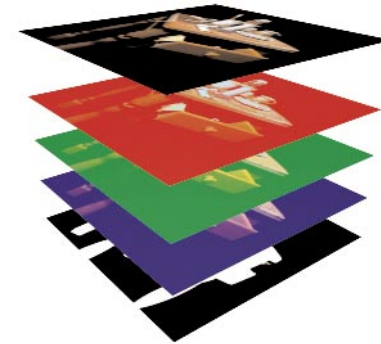
PIXELS

Up close, you can clearly see the grid of pixels that make up the bitmap image.



BITMAP CHANNELS

Each pixel is made up of at least three color values – red, green, and blue. These channels combine to create the visible color.



A bitmap image can be made up of many channels, each carrying information about the image. For a typical image, the channels would be red, green, blue, and alpha (RGBA). The alpha can be used to mask the other channels.

FULL RESOLUTION

As pixels are presented at a higher resolution, the grid is no longer visible and you get a clearer view of the final image.

BITMAP SOURCES

Bitmap images are common in computer graphics and can be created and manipulated in paint, compositing, and 3D rendering packages.

IMAGE AND DISPLAY RESOLUTION

Maya uses the term **Image resolution** to refer to the total pixel size of the bitmap image. **Display resolution** refers to how many pixels you will find in 1 inch on the screen. This resolution is measured in pixels per inch (ppi) or dots per inch (dpi). Monitors have a display resolution of about 72 dpi, although your graphics card may offer several settings which will alter this value.

As an animator, you will focus on producing images with a particular **Image resolution** such as 640 x 480 pixels for video or one of a variety of resolutions for film. The default **Display resolution** for these images is 72 dpi. If you are taking an image to print, you will need to consider a **Display resolution** of around 300 dpi. This value may be higher or lower depending on your printing needs. Below, you can see how different resolutions look when printed. You can see how the 300 dpi image provides a higher quality image on the printed page.



2" x 2" @ 72 DPI (144 X 144 PIXELS)



2" x 2" @ 150 DPI (300 X 300 PIXELS)



2" x 2" @ 300 DPI (600 X 600 PIXELS)

OTHER CHANNELS

In a typical bitmap, the first three channels contain color information. You can also create other channels that offer useful information about the image. Maya is able to render images with mask and depth channels for use in compositing packages. These channels can be used when you want to layer several images together seamlessly, including live-action plates created outside Maya.



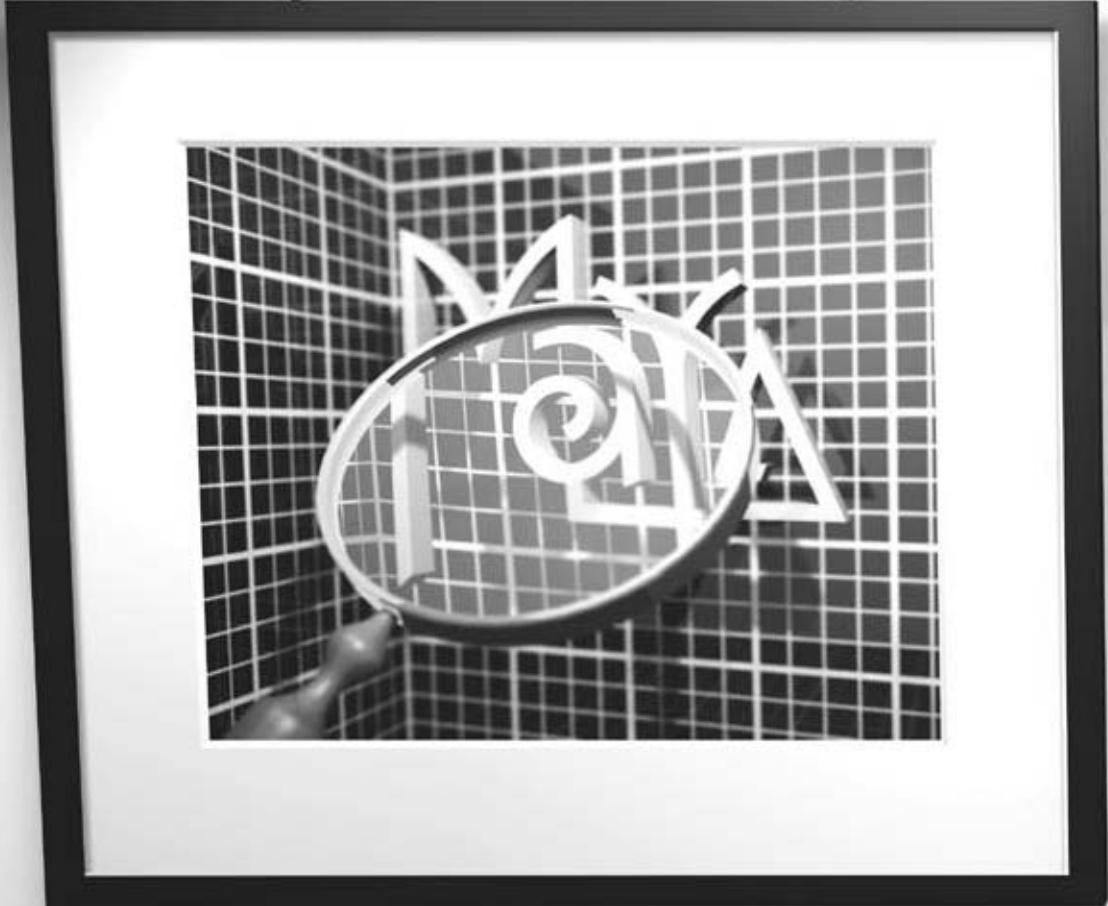
MASK CHANNEL

A mask (or alpha) channel, defines where an image needs to be solid or transparent. This channel can be used to layer images for compositing or to texture map attributes such as transparency or bump.



DEPTH CHANNEL

A depth channel can provide actual 3D information about an image. Images are very useful in a compositing package where you can combine layers or add effects such as fog or depth of field.



|exploring| maya

Before exploring modeling and animation concepts, it is a good idea to become familiar with the way Maya's user interface works. The user interface is where 3D artists display and organize scenes, save and open files, and transform and animate objects. While developing these skills 3D artists learn just how they can make Maya do what they want it to.

Maya has a very clean user interface where many of the elements share generic editor windows. At first, this may make it difficult to distinguish different parts of a scene, but with experience 3D artists learn the power of this paradigm. The generic way in which Maya presents information makes it very easy to transfer skills from one area of Maya to another. This lets 3D artists focus on learning Maya's underlying concepts instead of always re-learning how the user interface works.

Maya's Dependency Graph concept links virtually all objects in a scene to each other. As 3D artists learn more, they discover this underlying structure plays a key role in how they work and animate in Maya.



The Workspace

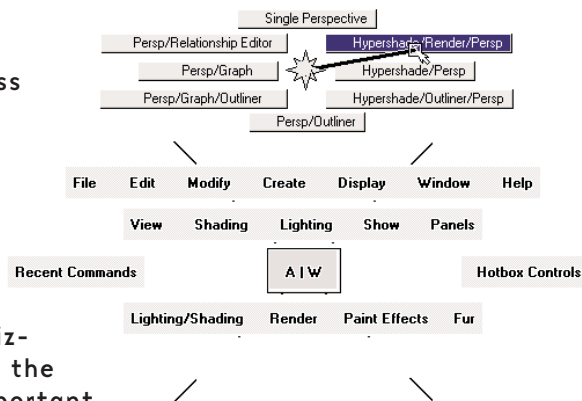
```
setAttr "spotLight1.rotateY" -type double3 0
56500 ; setAttr
spotLight1.translate" -type double3 0
63.764707; setAttr
```

The Workspace

Creating an animation in Maya involves the manipulation of many graphic elements such as curves, surfaces, colors, and textures. Information about these elements is stored in Maya as numeric values that can be viewed in a number of different ways. In Maya's workspace, you can choose how you want to view a scene and access different tools to alter its 3D information. Maya offers several ways of accessing and altering your scene, giving you the flexibility to build workflows that best suit the way you work.

THE HOTBOX

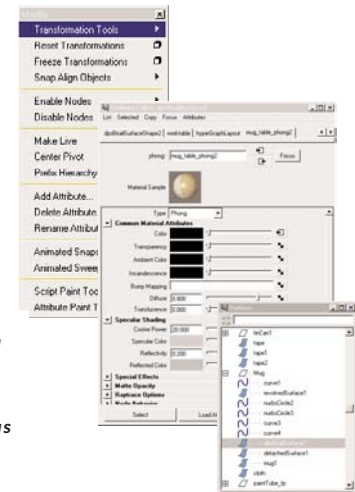
The Hotbox gives you access to all of Maya's menu items and tools right at your cursor position. When you press and hold down the **Space bar** on your keyboard, after a short delay the Hotbox appears. The Hotbox is fully customizable and lets you focus on the tools you feel are most important to your workflow. The **Hotbox Controls** let you turn off the main menus and the panel menus in the workspace. When the menus and panels are off, you can focus entirely on using the Hotbox.



Many UI panels can be set up as floating windows in case you need them just temporarily. Menus can also be broken off from the Main Menu bar in case you need to focus on the menu's contents.

USER INTERFACE ELEMENTS

When you first launch Maya, the workspace is presented to you with a number of user interface (UI) elements. Each is designed to help you work with your models, access tools, and edit object attributes. Initially, you should learn the locations of the UI elements so you can easily find them while you work.



MENU SETS

While Maya's first six menus are always available, the remaining menus change depending on which **Menu Set** you choose. This helps focus your work on related tools.

QWERTY TOOLS

The "qwerty" hotkeys can be used to Select (q), Move (w), Rotate (e), Scale (r), and Show Manipulators (t) as well as access the last tool used (y) in the scene.

QUICK LAYOUT BUTTONS

The Quick Layout Buttons provide predefined configurations of the Maya workspace. The Right Mouse Button over these buttons will also give access to more options.

TIME SLIDER

The Time Slider shows you the time range as defined by the range slider, the current time, and the keys on selected objects or characters. You can also use it to "scrub" through an animation.

MENUS

Menus contain tools and actions for creating and editing objects and setting up scenes. There is a main menu at the top of the Maya window and individual menus for the panels and option windows.

STATUS BAR

The Status Bar contains shortcuts for a number of menu items as well as tools for setting up object selection and snapping. A Quick Selection field is also available that can be set up for numeric input.

SHELF

The Shelf is available for you to set up customized tool sets that can be quickly accessed with a single click. You can set up shelves to support different workflows. Press **Shift+Ctrl+Alt** when selecting a menu item to add it to the Shelf.

CHANNEL BOX

The Channel Box lets you edit and key values for selected objects.

LAYERS

Maya has two types of layers. **Display Layers** are used to manage a scene, while **Render Layers** are used to set up render passes for compositing. In each case, there is a default layer where objects are initially placed upon creation.

PLAYBACK

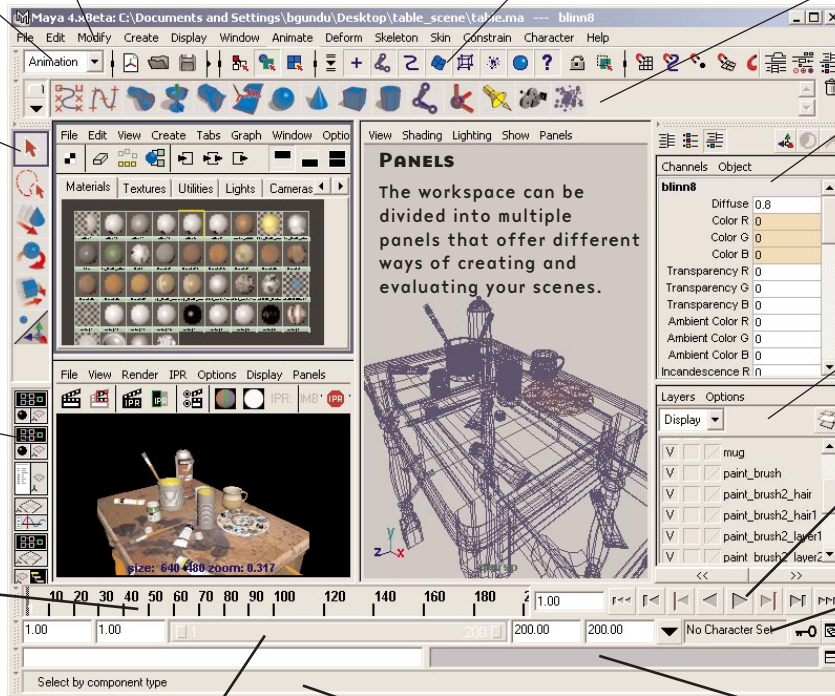
The Playback controls let you move around time and preview your animations as defined by the Time Slider range.

CHARACTERS

The Character Menu lets you define one or more characters, then prepare them for being animated.

COMMAND LINE

This bar has an area to the left for inputting simple MEL commands and an area to the right for feedback. You will use these areas if you choose to become familiar with Maya's MEL scripting language.



RANGE SLIDER

This bar lets you set up the start and end time of the scene's animation and a playback range if you want to focus on a smaller portion of the timeline.

HELP LINE

The Help Line gives a short description of tools and menu items as you scroll over them in the UI. This bar also prompts you with the steps required to complete a certain tool workflow.

```
setAttr "spotLight1.rotateY" -type double3 0
56500 ; setAttr
spotLight1.translate" -type double3 0
63.764707; setAttr
```

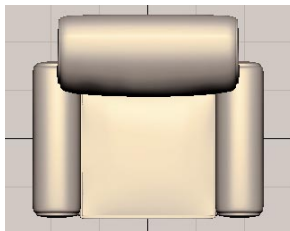


Viewing 3D Scenes

When building a scene in Maya, you work in three-dimensional space. Orthographic and perspective view cameras offer ways of looking at the objects in your scene as you work. There are also different display options that change the way objects in your scene are shaded.

DEFAULT VIEWS

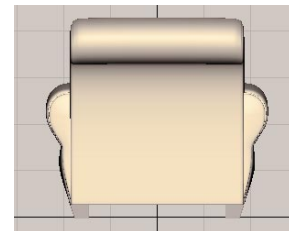
In Maya, the default views are set as Perspective, Top, Front, and Side. The Perspective view is a representation of your object in 3D space allowing you to move along the X, Y, and Z axis. The Top, Front, and Side views are referred to as orthographic views and allow you to move in two dimensions at a time.



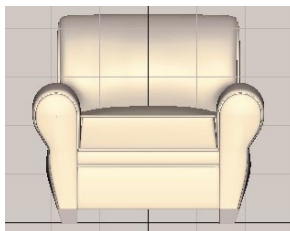
DEFAULT TOP VIEW



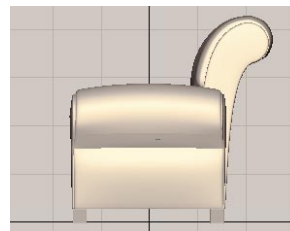
DEFAULT PERSPECTIVE VIEW



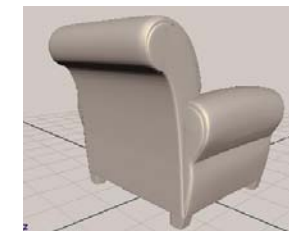
NEW BACK VIEW



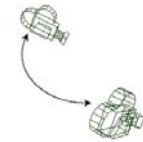
DEFAULT FRONT VIEW



DEFAULT SIDE VIEW

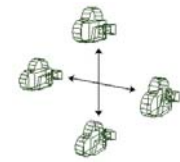


NEW PERSPECTIVE VIEW



TUMBLE

Press the **Alt** key plus the left mouse button to rotate the camera around a 3D perspective view.



TRACK

Press the **Alt** key plus the middle mouse button to pan from left to right, and up, and down.



DOLLY

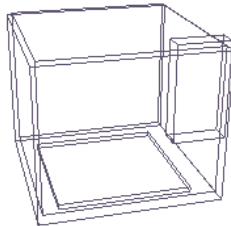
Press the **Alt** key plus the right mouse button to dolly in and out of your scene.

SHADING

Maya's Shading menu offers several options for displaying objects in a scene. Shading can be different for each view panel, allowing geometry to be shown at different levels of complexity.

The more detailed a scene becomes, the greater the need to simplify the objects in it. Although Maya is very good at processing complex levels of geometry, it is a good idea to view your objects in a less complex shading mode until you are ready to render or make adjustments to those objects.

There are several shading display options to choose from. The default shading in Maya is Wireframe. Other display options include: Bounding Box, Points, Flat Shade, Smooth Shade, Hardware Lighting, Wireframe on Shaded, and X-Ray.



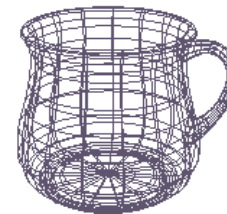
BOUNDING BOX

Bounding Box displays objects as boxes. This is useful when working with complex scenes.



POINTS

Points shading displays objects as a group of points that represent the shape of the object.



WIREFRAME

Wireframe shading is the default shading quality in Maya.



FLAT SHADE

Flat shade displays objects with lower resolution faceted display.



SMOOTH SHADE

Smooth Shade displays objects as smooth surfaces with surface color and shading properties.



HARDWARE TEXTURING

Hardware Texturing displays smooth-shaded surfaces with textures.



HARDWARE LIGHTING

Hardware Lighting displays smooth-shaded surfaces with textures and lighting.

SMOOTH AND FLAT SHADING

When choosing to view your objects as Smooth Shaded or Flat Shaded, Maya offers the option to shade only selected items in a view or all items in a view.

```
setAttr "spotLight1.rotateY" -type double3 0
56500 ; setAttr
spotLight1.translate" -type double3 0
63.764707; setAttr
```



Objects and Components

You can transform objects in Maya by selecting objects and their components. Selection masks allow you the flexibility to select only the items you want in a scene. These masks are grouped into three categories: Hierarchy, Object type, and Component type selections.

RENDERING

Scene objects such as lights, cameras, and textures are rendering object types.



CURVES

Turning off the Curve selection means you can not select the curves in the scene.



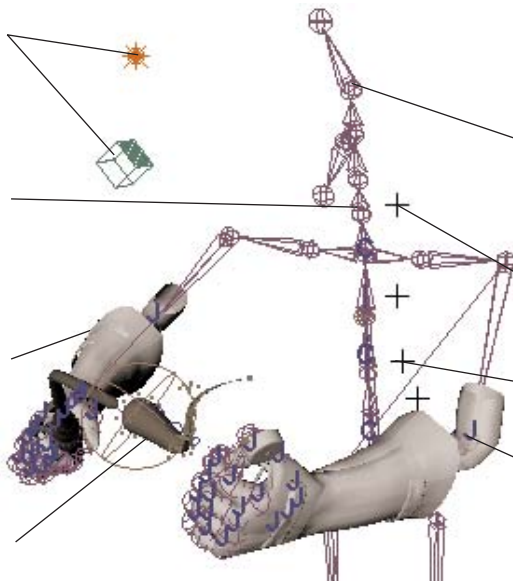
SURFACES

Selecting by Surfaces allows you to select the surface geometry of an object.



DYNAMICS

Dynamic objects such as particles can be separately selected by toggling the Dynamics button on.



OBJECT TYPES

Scene objects are items such as Cameras, Curves, Surfaces, Dynamics, Joints, Handles, and Deformers. Objects created in Maya are made up of two parts: a Transform node and a Shape node. The Transform node contains information about an object's position and orientation in space. The Shape node defines what the object looks like.

SKELETON JOINTS

Skeleton joints are used to help control characters.



HANDLES

IK handles are applied to joint chains for animation control.



DEFORMATIONS

Deformers such as cluster flexors and lattices modify the shape of an object.

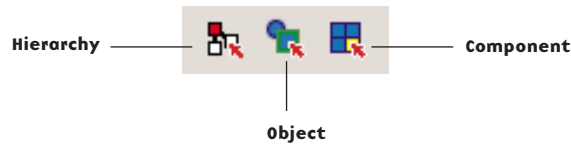


COMPONENT TYPES

In order to change the shape of an object in Maya, you need to modify component-type information.

There are a variety of component types such as points, isoparms, faces, hulls, pivot points and handles. These components can be used to interactively modify and reshape the appearance of an object.

SELECTION MASKS



Selection masks allow you to select the specific items you want to work on. There are three main groups of selection masks: Hierarchy, Object, and Component.

Hierarchy mode allows you to select nodes at different levels. In this mode you can select the Root, Leaf, and Template nodes.

Object mode allows you to select scene elements at the Transform node level. These include objects such as surfaces, curves, and joints.

Component-type selections are selections made to objects at the Shape node level, such as isoparms and CVs.

PARAM POINTS

Param points are points that lie directly on a curve or surface.

PIVOT POINTS

Pivot points determine the location around which transformations occur.

FACES

Faces are patches created by intersecting lines.

LINES

Lines such as isoparms and trim edges define the shape of an object.

POINTS

Points such as CVs and polygonal vertices are used to modify the shape of an object.

HULLS

Hulls are guides that connect CVs. They can be used to select and transform rows of CVs at once.



HIERARCHY

Selecting by Hierarchy allows you to select objects at either the Root, Leaf or Template node level. Unlike Object and Component selection masks, you are not able to turn on more than one mask at a time.



OBJECT

Object selection masks allow you to make selections based on the object types you specify. Left-clicking on the arrow to the left of the pick masks displays a menu allowing you to turn all objects on or off.



COMPONENT

Component selection masks offer a variety of pick masks to choose from. Right-clicking on a mask displays more selection options.

```
setAttr "spotLight1.rotate" -type double3 0
56500 ; setAttr
spotLight1.translate" -type double3 0
63.764707; setAttr
```

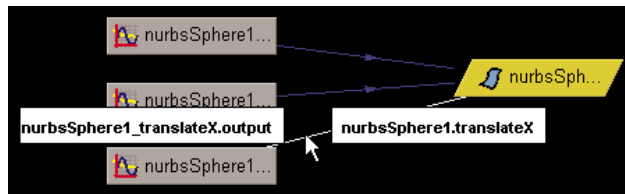


Dependency Graph

Everything in Maya is represented by a node with attributes that can be connected to other node attributes. This node-based architecture allows connections to be made between virtually everything in Maya. Node attributes determine such things as the shape, position, construction history and shading of an object. With this architecture, you can create inter-object dependencies, shading group dependencies, and make your own node connections.

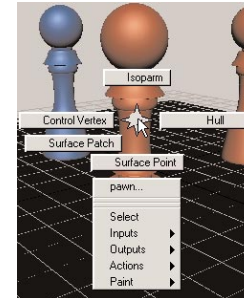
NODES WITH ATTRIBUTES THAT ARE CONNECTED

The Dependency Graph is a collection of nodes which are connected together. These connections allow information to move from one node to another and can be viewed in a diagrammatic fashion through the Hypergraph and Hypershade windows.



ANIMATION CURVE

When an animation is produced in Maya, node dependencies are created between the animation curves and the object being animated.



RIGHT MOUSE BUTTON

Clicking the right mouse button over a selected object will give you access to an object's input and output connections.

NODE DEPENDENCIES

In the diagram below you can see the nodes that are dependent on each other to make up a chess piece. Each node plays a part in creating the final rendered object. Here you see that the Material node is dependent on the Shape node to render the material, the Shape node is dependent on the revolve node for the chess piece surface, and the Revolve node is dependent on the Curve node to make the revolve.



VIEWING DEPENDENCIES

Dependencies are relationships created between nodes that are connected. There are many ways to view and edit dependencies in Maya including the Hypergraph, Attribute Editor, and Channel Box.

By selecting a node and clicking the Up and Downstream Connections button in the Hypergraph window, you can view node dependencies on a selected node. This window visually displays the connection between nodes with arrows showing the direction of their dependency to one another.

The Attribute Editor is made up of several tabs allowing you to view related nodes of a dependency group. In the Attribute editor, you can edit the attributes that affect these nodes.

In the Channel Box, the selected node is shown with a listing of any keyable attributes that belong to it. Depending on the node selected, it will also show input, output, or shape nodes. If you select more than one node with the same keyable attributes, you can modify them at the same time using the channel box.

ATTRIBUTE EDITOR

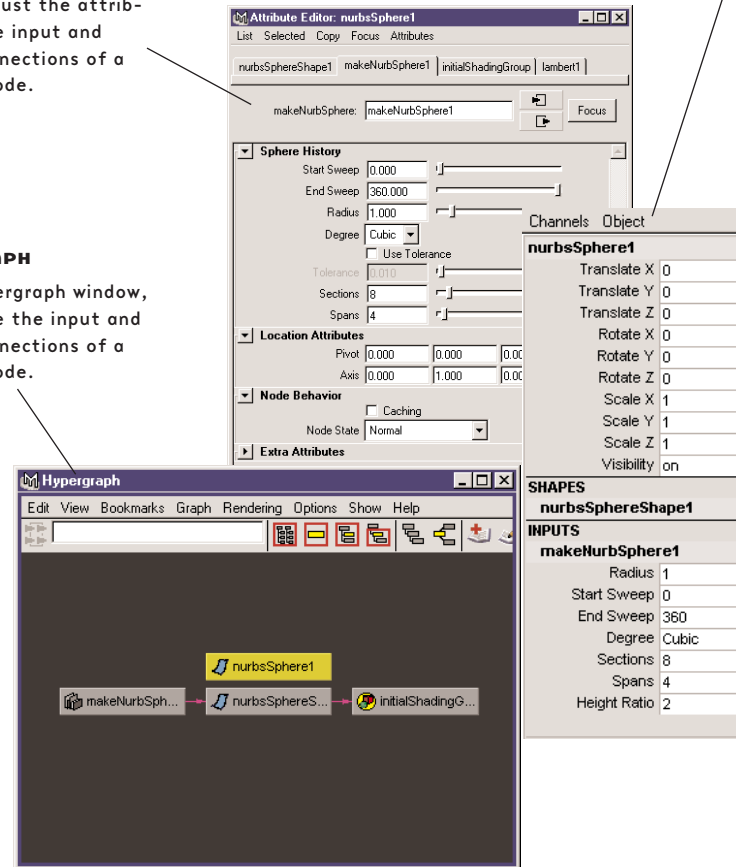
In the Attribute Editor, you can adjust the attributes on the input and output connections of a selected node.

HYPERGRAPH

In the Hypergraph window, you can see the input and output connections of a selected node.

CHANNEL BOX

In the Channel Box, you can edit any keyable attributes on the selected node.



```

setAttr "spotLight1.rotate" -type double3 0
56500 ; setAttr
spotLight1.translate" -type double3 0
63.764707, setAttr

```

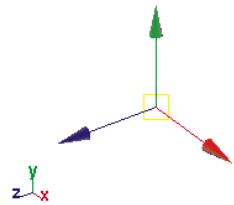


Transformations

Transformations are changes made to an object's position, orientation, and scale in space. The Transform node holds all of this information and the Transform manipulators such as the Move, Scale and Rotate Tools are used to transform an object along the X, Y, and Z axes.

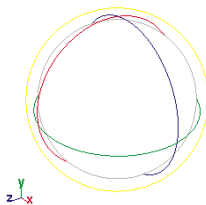
MANIPULATORS

Manipulators are used to move, scale, and rotate objects in orthographic and 3D space. Each of the manipulators uses red, green, and blue color handles matching the colors of the X, Y, Z locator at the bottom left corner of the view, making it easier to distinguish the direction of the transformation. These handles are designed to constrain the transformation to one, two, or three axes at a time, allowing for complete control.



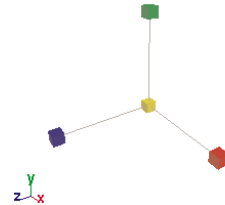
MOVE TOOL

The Move Tool has a handle for each X, Y, and Z axis and a center handle to move relative to the view.



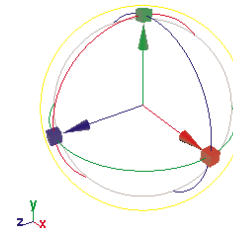
ROTATE TOOL

The Rotate Tool has a ring for the X, Y, and Z axes. One ring moves relative to the view, and a virtual sphere rotates in all directions.



SCALE TOOL

With the Scale Tool, you can scale non-proportionally in X, Y, or Z. You can also scale proportionally by selecting the center handle.



MOVE/ROTATE/SCALE TOOL

This Tool incorporates the Move, Rotate, and Scale manipulators into one tool. Select **Modify > Transformation Tools > Move/Rotate/Scale Tool** to use this Tool.

TRANSFORMATION TOOLS

To work quickly and efficiently in Maya, the QWERTY Hotkeys offer a fast way to access the transformation tools. These tools are located at the top left corner of the Maya workspace. Select, Move, Rotate, Scale, and the Show Manipulators Tools plus an extra space for the last tool you used, are all a part of the QWERTY tool set.

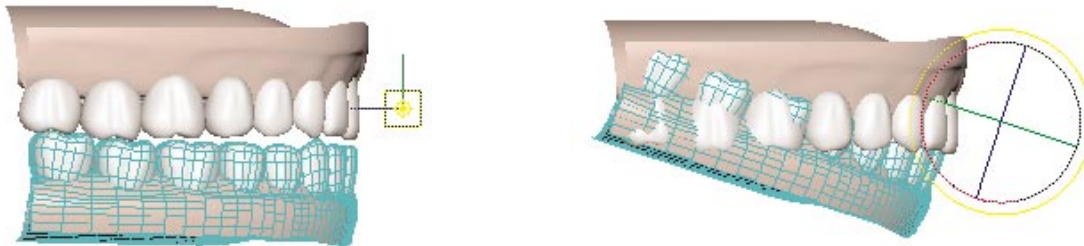


q w e r t y

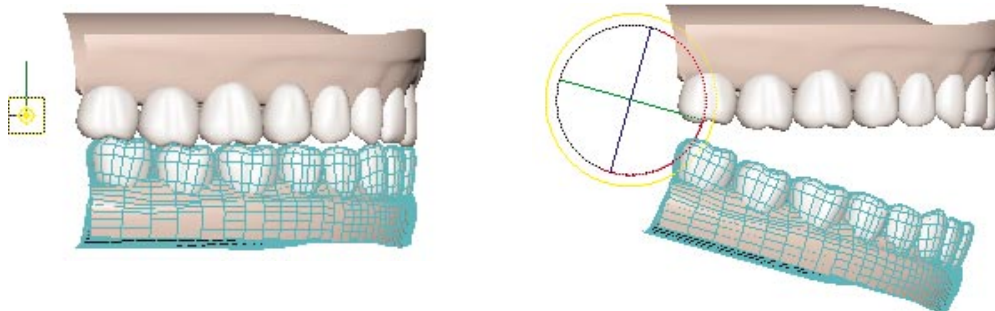
Use the QWERTY shortcut keys on your keyboard to select and transform the objects in your scene.

SETTING PIVOT POINTS FOR TRANSFORMATIONS

Objects are transformed around their pivot point location. This is important to be aware of because the position of your pivot point affects the outcome of your transformation. To change the location of your pivot point, select a Transform Manipulator and press the **Insert** key on the keyboard. Move your pivot point to the desired location and press the Insert key again to set the pivot point.



Pivot point is in the wrong location.



Object is rotating around a properly positioned pivot point.

RESET TRANSFORMATIONS

Once you have manipulated an object, you may not be satisfied with its new transformation. To reset your object to its original position, select **Modify > Reset Transformations**.

FREEZE TRANSFORMATIONS

Select **Modify > Freeze Transformations** to keep your current position as the default position. This means that your modified position will have values of 0 for Move and Rotate in the X, Y, and Z axes and a value of 1 for Scale.

2D TRANSFORMATIONS

When transforming an object using the Move Tool in the Top, Front and Side views, you are constrained to move only in two dimensions.

When using the Rotate and Scale tools in an orthographic view, you can transform an object in both two and three dimensions.



| animation

When 3D artists animate, they paint with motion instead of color. As an object moves, rotates, or changes shape over time, it is being animated. This motion can be at a constant speed or it can accelerate or decelerate. At times, this motion will attempt to mimic real-world events such as an object falling off a table, while at other times, it will take the form of an actor telling an audience a story.

Models that are animated must be set up with mechanical properties that define how they work. To have a door open and close or a drawer slide in and out, 3D artists must understand the mechanics of their models so they can animate them.

There are a number of tools for creating motion in Maya. In some cases 3D artists will animate all the parts of an object separately. In others cases, they use higher level controls to help streamline their workflow. Situations can even be set up where the animation of one object controls that of another.

```

setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707 ; setAttr

```



Animation Techniques

When you animate, you bring to life otherwise static and motionless objects. You take aspects of the object such as its position, size, shape, and color and change these over time. If these changes are set up properly, you create motion that instills character and life in the object.

In Maya, there are a number of ways to animate an object. Using a bouncing ball as a common example, it is possible to explore the different animation techniques available in Maya. In a real project, you will most often combine several of these techniques to achieve the best results.

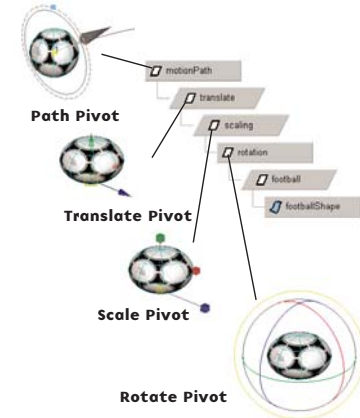
SETTING KEYS

Setting keys, or keyframing, is the most fundamental technique for animating in 3D on a computer. This technique involves recording attribute values as keys for one or more objects at particular points in time. As you set multiple keys, you can play back the scene to see your object animated.

Setting keys gives you a great deal of control over timing. When you animate using keys, you generate animation curves that plot the key values against time. These curves are great tools for analyzing and editing the motion of an object. Other animation techniques are usually combined with some keyframing. Most animation you do in Maya will involve some form of setting keys.

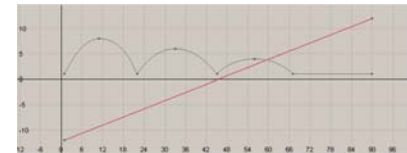
KEYING ATTRIBUTES

By setting keys on attributes at different times, you define the motion of an object. For example, Translate X is keyed at the beginning and end of the bounce. Translate Y is keyed with an up and down motion that is fast near the ground and slow near the peak of the bounce.



HIERARCHICAL ANIMATION

You set many of your keys on the Transform nodes of your object. By grouping an object to itself, you can set up different nodes with their own pivot points and orientation, then key them on their own.



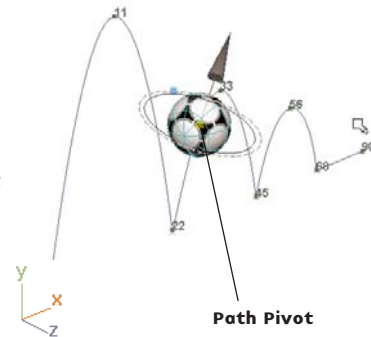
ANIMATION CURVES

By setting keys, you map the attribute's value to time. The keyframes are then connected by an animation curve that helps define the attribute in between the keys. Maya's Graph Editor shows you the speed of the motion and lets you reshape the curve.

PATH ANIMATION

Path animation involves attaching the object to a curve where points on the path are used to determine where the object will be at particular points in time. It is easy to understand the way an object moves around in 3D space through a path, since its curve clearly depicts where the object is going.

A curve is used to represent the path of the bouncing ball. This method lets you describe the path of the bounce by shaping the curve, but timing the bounce requires the setting of several motion path keys to lock down the motion.



EXPRESSIONS

Another way of animating object attributes is through expressions. Expressions can be mathematical equations, conditional statements, or MEL commands that define the value of a given attribute. Expressions are evaluated on every frame. You can animate using an expression when you have a mathematical relationship that you want to achieve. In the case below, the absolute value of a sine wave creates the bounce of the ball.

SET DRIVEN KEY

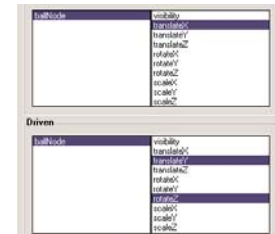
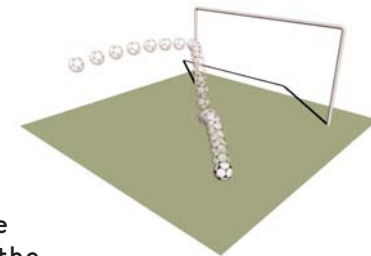
Set Driven Key allows you to control, or "drive", the value of one attribute with another attribute. The relationship between the two attributes is defined by an animation curve. The driving attribute can be used to drive multiple attributes. For example, the rotation of an elbow joint could drive a bulging bicep muscle and the wrinkling of a sleeve.

Custom attributes can be added to a control node, then connected to other attributes in the scene using Set Driven Key. This creates centralized controls.

DYNAMIC SIMULATION

To animate a ball that is bouncing off a series of objects or against a non-flat terrain, a dynamics simulation is required for the most realistic results. The ball can be turned into a rigid-body that is propelled forward using dynamic attributes. Forces such as gravity or wind can then be applied to the ball to bring it to the ground.

Objects in the scene can also be turned into rigid-bodies so the ball will collide with them. If they are passive, they will not be affected by the collision, and if they are active rigid-bodies, they will move as the ball hits them. In the end, the simulation can be baked to turn the motion into keys.



DRIVERS

Set Driven Key lets you use one attribute to drive other attributes. Here the Translate X of the ball drives the Translate Y and roll of the ball. As the ball moves forward, the bouncing action takes place.

```
setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707 ; setAttr
```



Setting Keys

For an object to be animated, it must change over time. For example, a car might move forward or a light might blink on and off. To animate these changes in Maya, you need to set keys for the car's Translate X attribute or for the light's intensity. Keys are used to mark attribute values at specific times. Then, animation curves are used to determine the value in between the keys.

As a 3D artist, setting keys is one of your most important techniques. This animation technique can be easily applied to your objects and the results can be easily edited. Once you are familiar with this technique, you will soon find that you spend less time setting keys and more time editing the motion.

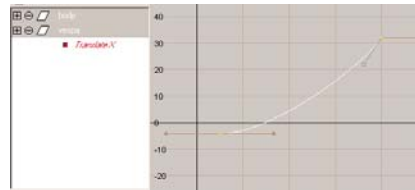
KEYING ATTRIBUTES

When you set keys, you key values for one or more of an object's attributes at specific frames in time. These keyframes set the values, while tangents set at each key determine the interpolation in between the keys. This interpolation results in an animation curve that can be edited in the Graph Editor. This editing feature helps you control the quality of your motion.



STEP 1: KEYFRAMES

Keys are set for at least two points in time. You can set keys for one or more attributes at the same time. The keys are then stored as animation curves.



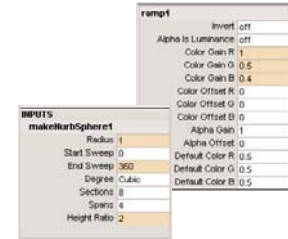
STEP 2: ANIMATION CURVE SHAPE

In the Graph Editor, you can view and edit the animation curves. At each key, there are tangents set that define the shape of the curve.



STEP 3: PLAYBACK

When you play back an animation, the object uses the keys and the values defined by the animation curve to create the resulting motion.

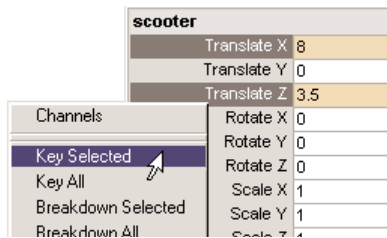


KEYING ATTRIBUTES

In Maya, virtually every attribute is keyable. As you learn more about the different nodes available in Maya, you will begin to discover unique possibilities for animating your models. For example, if you keep an object's Construction History, you can set keys on the Input node's history. You can also set keys on attributes belonging to lights, materials, cameras, and other node types.

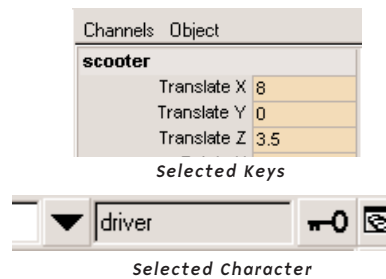
HOW TO SET KEYS

There are a number of ways to set keys in Maya. Each one offers a different way of recording time and value information. In some cases, you may want to set keys for a number of objects, and in others, you may want to set keys for a single attribute. The results are always the same as animation curves are created for any attribute for which you set a keyframe. The only difference lies in choosing a workflow that meets your needs.



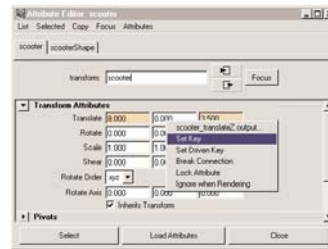
CHANNEL BOX

The Channel Box always displays the keyable attributes of a selected object. The Channel Box also lets you highlight one or more channels and then select **Channels > Key Selected** to set keys for the highlighted attributes on all the selected objects.



SET KEY

The **Animate > Set Key** tool is designed to create keys for as many keyable attributes that exist on selected objects or characters. If a character is selected from the character pop-up then it is keyed. Otherwise the selected object is keyed.

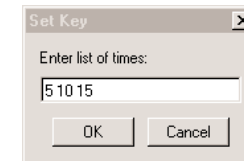


ATTRIBUTE EDITOR

When viewing attributes in the Attribute Editor, you can click the right mouse button over individual attributes and choose **Set Key**. Since this window shows both keyable and non-keyable attributes, you can use this method if you need to key an attribute that does not appear in the channel box.

HOT KEYS

A fast and easy method for setting keys is through Hot Keys. Hitting the **s** key will set a keyframe for all keyable attributes on the selected object or character set. **shift w**, **shift e**, **shift r**, will set keys for just the translation, rotation, or scale of an object.



PROMPT

One of the **Set Key** options is to use a prompt window to let you set the keys for multiple points in time. For example, you could set a key for frames 5, 10, and 15 all at once using this window. The same attribute value would be keyed for each of these times.



Autokey Off



AutoKey On

AUTO KEY

Auto Key lets you key automatically as you edit objects in your 3D views. Auto Key will set keys whenever the value of an animated attribute is changed. Make sure to turn this option off when you have finished using it.

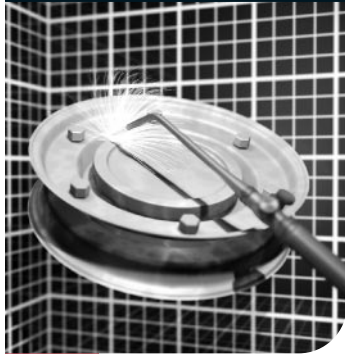


| modeling

Modeling is the process of creating shape and form on screen. Models in Maya can be hard objects with sharp edges or organic objects with a softer look. Using one of several geometry types, 3D artists can build surfaces, then push and pull points to change their shape.

Modeling on the computer can be a challenge at first because the goal is to mimic three-dimensional objects on a two-dimensional screen. In this chapter, 3D artists will learn how to use manipulators and different view panels to navigate this virtual world so they can focus on sculpting and building their models.

While building good looking models is important, 3D artists must also be aware of how the model will be used down the line. Models might need to bend or twist or simply move around your scene. Also, how surfaces are texture mapped will depend on how they were built. Therefore, 3D artists must make important choices at the outset about what kind of geometry they need and how it will support their animation pipeline.



Geometry

```
setAttr "spotLight1.rotate" -type double3 0  
2.56598 ; setAttr  
"spotLight1.translate" -type double3 0  
65.764707 ; setAttr
```

Geometry

The mathematics of geometry is used by the computer to determine what you see on the screen. Maya's user interface gives you tools to edit geometry without having to understand the math behind it.

In order to build complex scenes, you need to understand how to manipulate geometry and how the geometry will be animated and texture-mapped down the line. A good-looking model is only complete when it satisfies the needs of all aspects of the animation process.

POINTS, CURVES, AND SURFACES

Points, curves, and surfaces are the basic geometric elements that you will use to create and manipulate 3D objects on the computer.

The creation of surfaces from points and curves is the essence of modeling in Maya. Sometimes, you start with an existing surface and manipulate its points to define shape and form. Other times you start with carefully constructed lines or curves that are then used to build a surface. Either way, you will work to give a physical presence to these basic geometric elements.

CURVES

When two or more points are connected, you have a curve. Curves are useful for defining the shape of an object. They can also be used as paths for animating objects. Since curves only have one dimension, they cannot be rendered. Instead, they can play a key role in defining how surfaces work in 3D space.

SURFACES

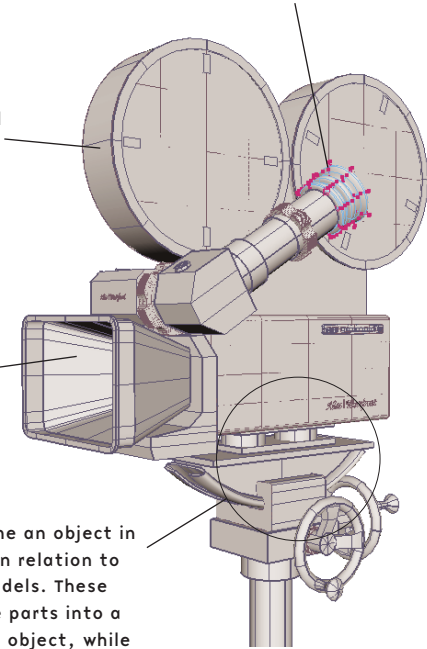
When a series of lines are connected in two directions, you have a surface. Surfaces can be textured and rendered to create 3D images. When you shine light onto a surface, you can see the shape of the surface as gradations of tone and highlight.

OBJECTS

One surface is often not enough to fully define an object in 3D. When a series of surfaces are positioned in relation to each other, you begin to get more complex models. These models require grouping to bring together the parts into a selectable hierarchy that can work as a single object, while not denying you access to the individual parts.

POINTS

Points are defined in three dimensions using XYZ coordinates. In Maya, control points are used to help define the shape of object types such as curves (CVs), surfaces (vertices, edit points), and lattice deformers (lattice points). Points are also very useful as references for snapping.



GEOMETRY TYPES

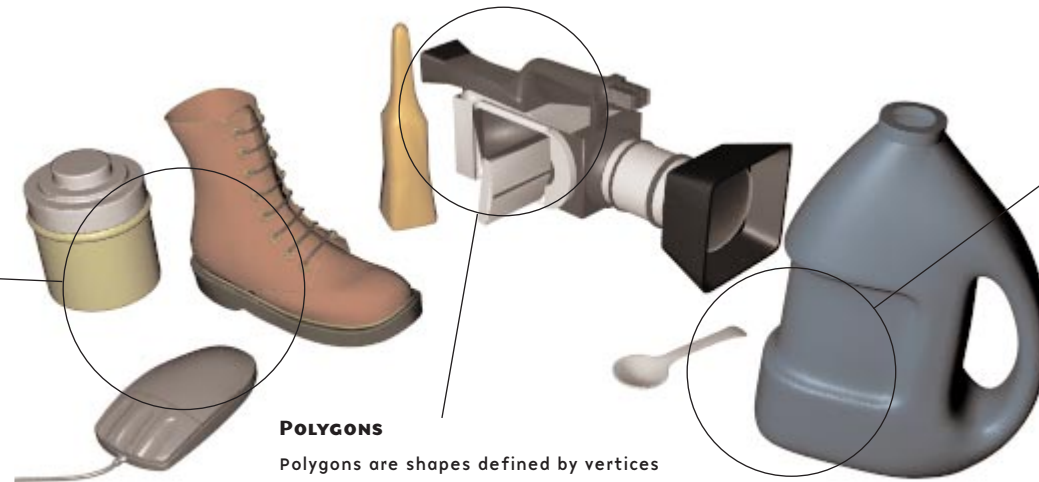
One of the first decisions you have to make when you start a project is how you are going to build your models. There are four types of geometry—polygons, NURBS, Subdivision, and Bezier surfaces.

You can use any geometry type to create either simple or complex models. You can use one geometry type as a starting point for another or you can build models that combine geometry types. In general if you are building organic shapes, you will probably use NURBS or Subdivision surfaces. They will give you smooth surfaces and have the fewest control points which make edits to the surface easier. Since NURBS are

limited to a four-sided patch, there are limitations to the types of organic shapes you can make from a single surface. This is where it is beneficial to use Subdivision Surfaces because they can represent many more types of shapes with a single surface. If you are building non-organic shapes such as a desk, or wall, it is easier to use polygons because they easily make shapes like corners or edges. If you are building a surface that combines hard edges with an organic shape, Subdivision Surfaces work well. In this chapter, you will learn more about your options so you can decide on the geometry that best suits the way you want to work.

NURBS

NURBS geometry is spline-based. The geometry is derived from curves and surfaces approximated from the surface's control vertices (points) locations. NURBS allow you to start with curves that are then used to generate surfaces. This workflow offers precise results that can be easily controlled. All NURBS surfaces are four-sided patches, although this shape can be altered using the Trim tool.



POLYGONS

Polygons are shapes defined by vertices that create three, four or n-sided shapes. Polygonal objects are made up of many polygons. Polygons can appear flat when rendered, or the Normals across adjacent faces can be interpolated to appear smooth.

SUBDIVISION SURFACES

To create objects with Subdivision surfaces, you need some understanding of both NURBS and polygonal modeling. Subdivision surfaces are mostly built using a polygon mesh as a base and then refined. The advantage of using this geometry type is that detail is added only where needed, and it creates smooth surfaces like NURBS but does not have the limitations of being four-sided patches.



NURBS Curves

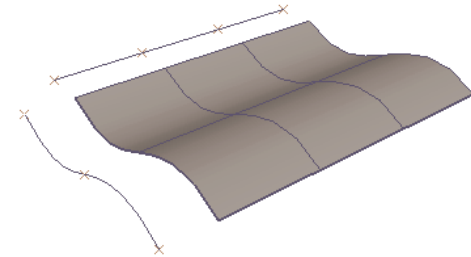
```
setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
f "spotLight1.translate" -type double3 0
65.764707 ; setAttr
```

NURBS Curves

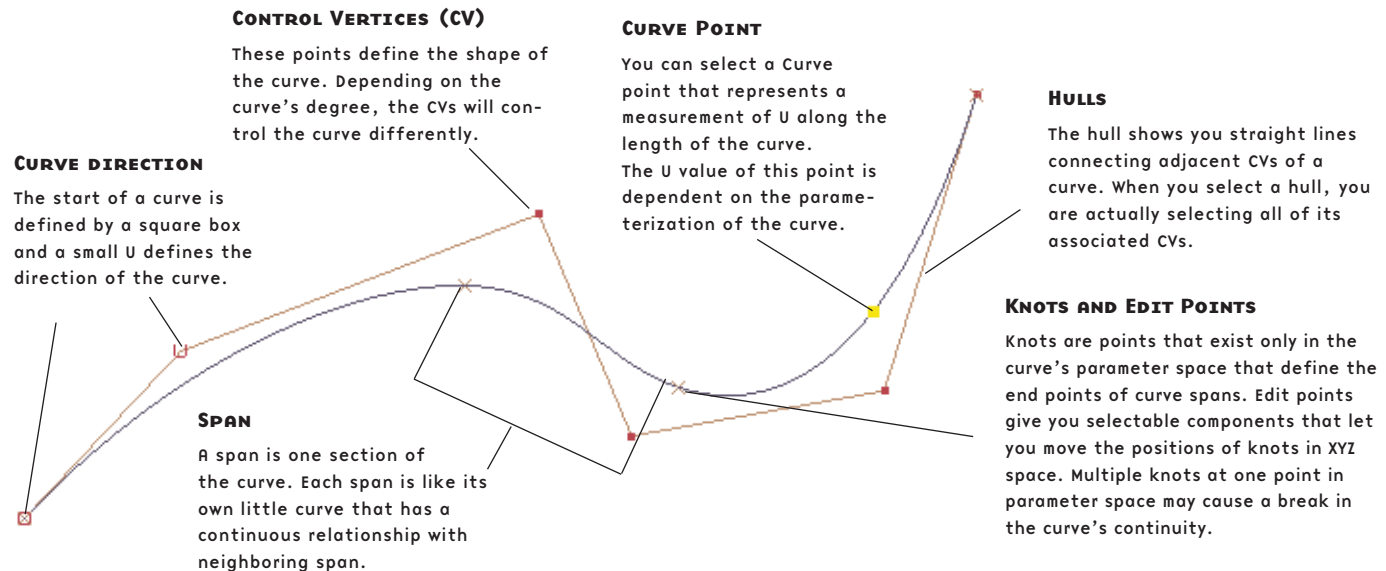
Curves are an important tool for working in 3D. They can provide a simple shape for modeling a surface or controlling an inverse kinematics (IK) solution. You can use them to cut holes in a surface or as a path for animating an object.

ANATOMY OF A CURVE

A Non-Rational Uniform B-Spline (NURBS) curve is defined by control vertices (CVs) that control the shape of the curve. The resultant curve approximates the path drawn through the CVs. NURBS curves also have other types of control such as edit points and hulls that help you work with and understand the shape of the curve.



When a curve is used to build a surface, the curve's number of spans have a direct influence on the topology of the resulting surface.



CV CURVE



This tool lets you create a curve with very fine control over its shape. Since the CVs lie off the curve, except at end points, you don't have direct control of the positioning of edit points.

EDIT POINT CURVE



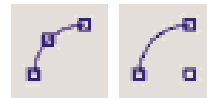
Drawing a curve with edit points, allows you to accurately snap the points to other curves to make sure they intersect. Drawing this type of curve is quite different than a CV curve.

PENCIL



The pencil line draws a curve by capturing your mouse stroke. This tool is good for getting rougher looking lines but may generate too many CVs. You may need to rebuild the curve later.

2- AND 3-POINT ARC



These tools let you control the shape of the arc. Radius information is available and later you can edit the arc history using the Show Manipulator Tool.

CIRCLE AND SQUARE



These primitive shapes create History nodes for editing attributes such as length and radius. You can edit these using the Show Manipulator tool or in the Channel Box.

TEXT



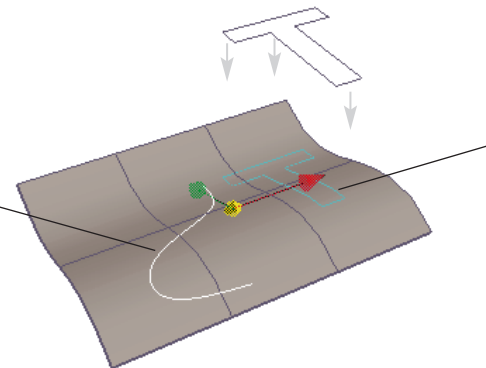
This tool creates NURBS curves that outline text using any of the fonts available on your system. You can also import outlined text from a vector based application.

CURVES-ON-SURFACE

While most curves are created in the XYZ coordinate world, some curves can be drawn directly on a surface. These curves-on-surface live in the UV coordinate space of the surface. These curves are often used to add a hole or a more complex edge to a NURBS surface by trimming the surface. Curves-on-surface can also be used as motion paths so that objects animate along the surface.

DRAWING

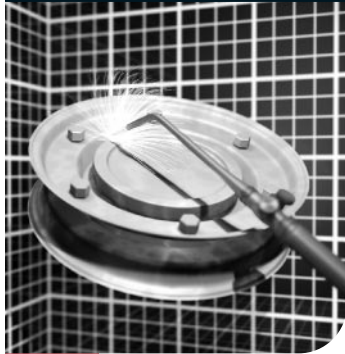
You can use the Make Live button to allow you to draw a curve into the surface's UV space. You can also edit control points in UV.



PROJECTING

You can project a curve that lies in 3D space onto the surface. This creates a curve-on-surface that lies within the UV of the surface.

You can also get a curve-on-surface by intersecting two surfaces.



NURBS Surfaces

```
setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707 ; setAttr
```

NURBS Surfaces

The foundation of a NURBS surface is the NURBS curve. To create NURBS surfaces efficiently, you must be proficient in creating good curves. The same principles behind NURBS curves are applied to NURBS surfaces since the two are related. There is an obvious difference: a NURBS curve has only one direction, while the NURBS surface has two directions. The two directions on a NURBS surface have an origin and together they define the Normals of the surface which determine the front and back of the surface. Being aware of these surface properties will help when using certain modeling and rendering operations such as Attaching surfaces or texture placement.

ANATOMY OF A NURBS SURFACE

The components of the NURBS surface are very similar to those of the NURBS curve, except the edit points are not moveable. NURBS surfaces have CVs, hulls, and spans which define the shape of a four-sided surface. NURBS models, whether they are organic or industrial in nature, generally are made up of several adjoining four sided patches. As with the NURBS curve, it is desirable to define surfaces with the fewest evenly spaced isoparms or CVs. As earlier stated, the quality and type of curve will affect the characteristics of the surface. However, the surface parameterization can be modified after creation by duplicating the surface curves at the desired locations and re-lofting.

ISOPARMS

Isoparms are lines that represent cross-sections in the U and V directions. Isoparms can be inserted, removed, used to make curves, and snapped to. If you select an isoparm that's not a span or section, it displays as yellow dots. If you select an isoparm that is a span or section, it displays as a solid yellow line. This distinction is important for some modeling actions.

SURFACE ORIGIN

Turning on this display option highlights the first U and V isoparms (red and green) and labels them U and V. It also draws a line indicating the surface Normal direction (blue).

CONTROL VERTICES

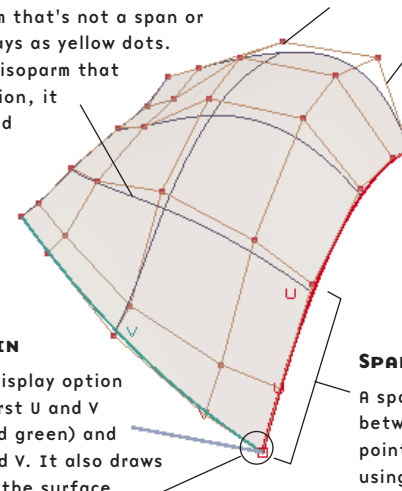
They do not exist on the actual surface but are used to manipulate the shape of the surface.

HULLS

The hull comprises straight lines that connect CVs. When you select a hull, you are actually selecting all of its associated CVs. the hull offers a better visual cue for the distribution of CVs in a crowded area.

SPANS

A span or segment is the space between isoparms at edit points. When creating surfaces using Revolve, Primitives, and Loft, or rebuilding them, you can specify the amount of segments or spans.



BUILDING SURFACES

The majority of the surfacing tools begin with creating curves defining the surface. In some cases the curves are used to create simple surface which are then rebuilt and modified by CV manipulation. Other times the curves are used to create much more complex surfaces that would be difficult to attain otherwise. To help you understand the operation of the tools, view the Help Line as you scroll through the menus.

Loft: Select curve(s), isoparm(s) or trim edge(s)

BIRAIL SURFACE

The Birail Tool creates a surface by using two or more profile curves that sweep along two rails. The profile curves must intersect the rail curves to create a surface. Profile and rail curves can be isoparms, curves-on-surface, trim boundaries, or boundary curves of an existing surface. The advantage of this tool over the Loft is greater control with the addition of rails.



PRIMITIVES

NURBS primitives are common geometric objects such as spheres, cubes, and cylinders. Primitives are often used as the foundation for other shapes.



TRIM SURFACE

To create a trimmed surface, a closed Curve on Surface is required. There are various ways of creating these curves.



EXTRUDE SURFACE

The Extrude tool creates a surface by sweeping a cross-sectional profile curve along a path curve. The profile curve can be an open or closed curve, a surface isoparm, a curve-on-surface, or a trim boundary. The extruded surface on this model create a lip for the scooter surfaces and give the illusion of depth.



FILLET BLEND SURFACE

The Fillet Tool creates a seamless blend between two surfaces. The three types are: Circular Fillet, Freeform Fillet, and Fillet Blend.



LOFT SURFACE

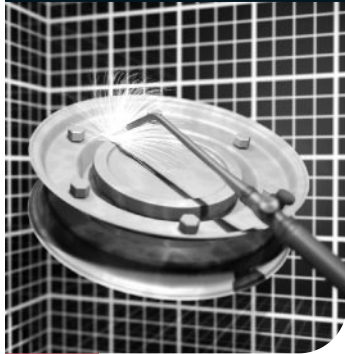
a Loft surface is created when a surface is applied to a series of profile curves that define a frame. There must be at least two curves or surface isoparms, and ideally the same parameterization for each curve, to achieve a clean surface. If the curves have the same curve degree and parameterization, the Loft surface will have the same number of spans in the U-direction.



REVOLVE SURFACE

The Revolve tool creates a surface defined by a profile curve that revolves around a defined axis. The use of construction history is very useful to tweak the shape after the revolve operation. The front fender began as a revolved surface that was then scaled, deformed and finally trimmed. The tire and rims are simple revolves.





Polygon Modeling

Polygons can be defined as a number of connected points that create a shape or face. Points are connected by edges that surround the resulting face. A face can exist as triangles, quadrangles (quads), or n-gons. Joined together, they create a polygon mesh. A polygon mesh can either consist of the Primitives that come with Maya, can be a complex shape that results from using Maya's polygon editing operations, or can be a mesh resulting from a Nurbs to Polygon conversion.

POLYGON COMPONENTS

Each polygon mesh consists of components that are modifiable to help create and edit the mesh. These main components are vertices, edges, faces, and UVs. There are polygon editing operations in Maya that allow you to edit these components. While you will need to select the individual components you wish to modify, by setting **Convert Selection to On** in the **Polygons > Tool Options** menu, Maya will automatically switch to the right component type for a given edit operation and perform the operation as instructed.

EDGES

Edges connect vertices by drawing a straight line between them. A single edge can be moved, scaled, or rotated. Press **F10** for Edge selection mode.

FACES

A face is made up of three or more connected edges. A face with three sides is a triangle, with four sides is a quad, and with more than four sides is a n-gon. A face can be moved, scaled, or rotated. Press **F11** for Face selection mode.

Selected Vertices

VERTICES

A vertex is a point in 3D space. Three or more connected vertices make a face. Press **F9** for Vertex selection mode.

Selected Edges

Selected UVs

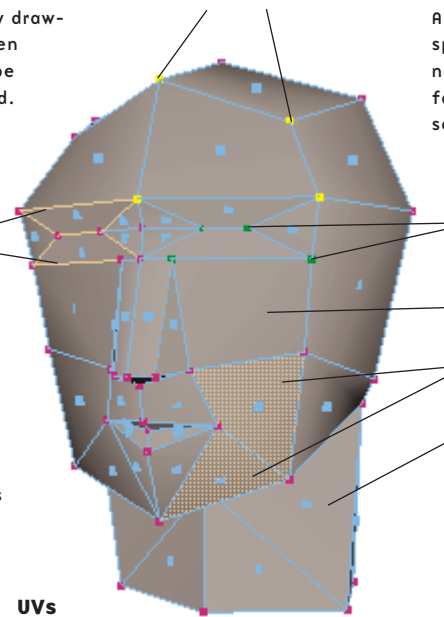
Quad

Selected Faces

Triangle

UVs

UVs are the two-dimensional coordinates that are required to display or render a texture on a mesh. A UV directly corresponds to a vertex on the mesh. Press **F12** for UV selection mode.

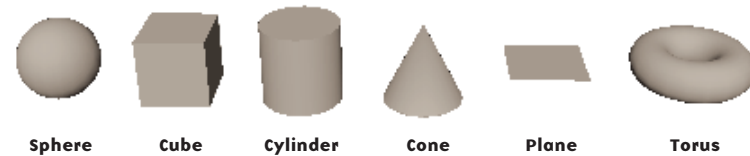


Polygon Modeling

```
setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707 ; setAttr
```

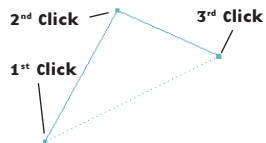

POLYGON PRIMITIVES

Maya includes a number of polygon Primitives that can give you a starting point for your model. These Primitives, with the exception of the plane, are closed shapes and all Primitives are created with a default set of UV information. These Primitives have construction history and their subdivisions can be modified before or after creation.

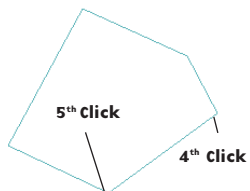


POLYGON CREATION

To create a polygon shape, select **Polys** > **Create Polygon Tool**. After placing a point, use the middle mouse button to alter its position.



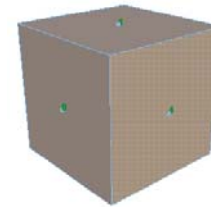
After the 3rd click, the polygon can be completed by pressing **Enter**. The dashed line represents the final edge.



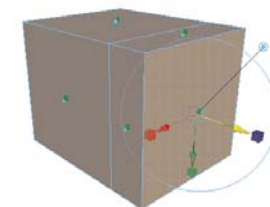
You can continue to place points until the desired shape is achieved. Press **Enter** to finish.

EXTRUDING FACES

You can further refine your shape by extruding the face of a polygon. This extrusion operation inserts faces at the edges of the face to be extruded and allows the selected face or faces to be moved, scaled, or rotated from their original position. If you are extruding multiple faces and want them to maintain a cohesive shape, set **Polys** > **Tool Options** > **Keep Faces Together** to **On**. This only inserts faces at the edges on the border of the selected faces. Otherwise, faces will be inserted at every edge. This tool can be found under **Edit Polys** > **Extrude Face**.



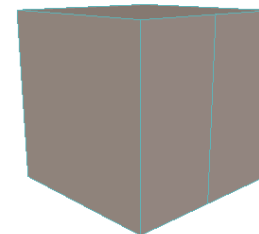
Face four is selected. This is the face that will be extruded.



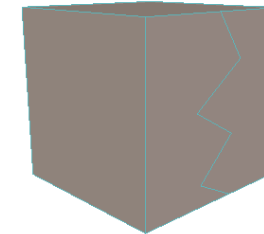
After the extrude is complete your faces are added at the edges of the extruded face.

SPLITTING POLYGONS

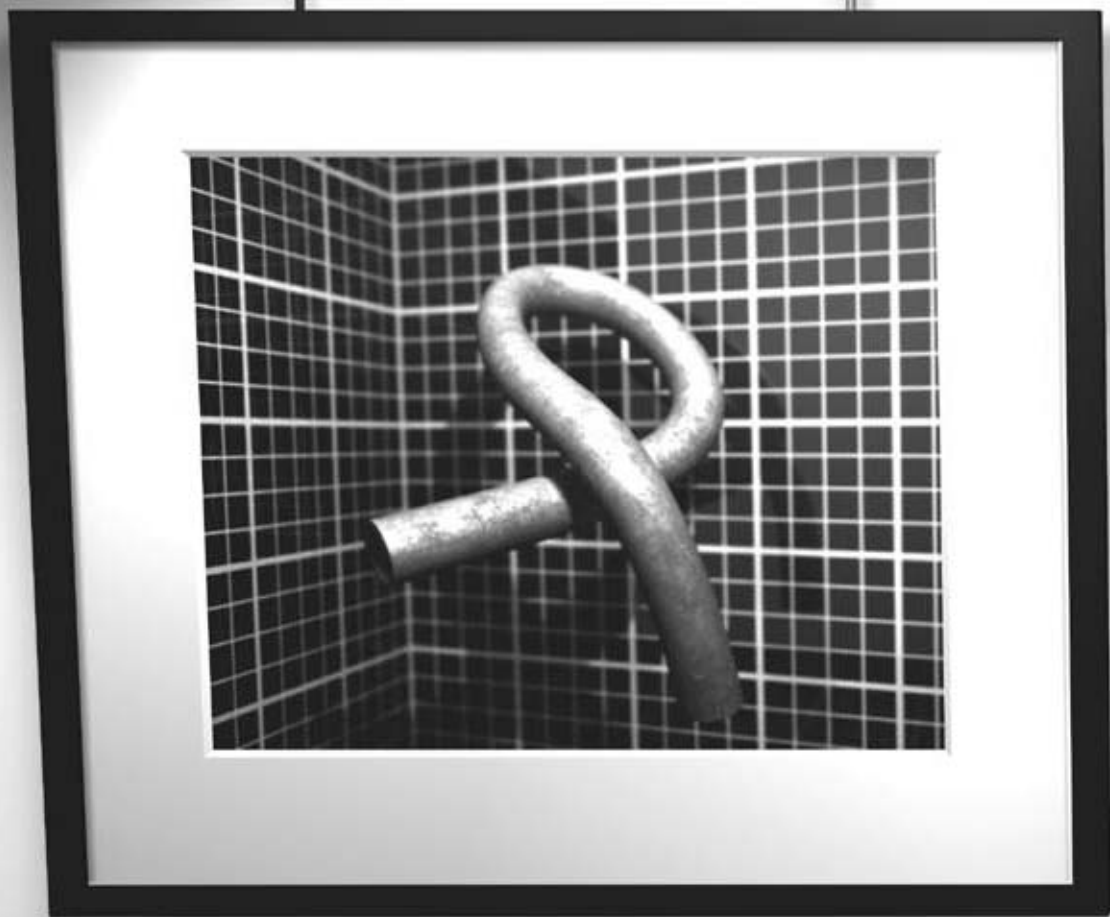
The Split Polygon Tool allows you to divide a polygonal face. You can also use the Tool to insert vertices on an edge. To assist you, the Tool has options that allow you to set how many Snapping Magnets you want and the Snapping Tolerance for the magnets. By setting Snapping Magnets to 3, the edge being split will have three equally spaced division points. Increasing the Snapping Tolerance increases the influence of the magnets. With a Snapping Tolerance of 0, the vertex can be added anywhere on the edge. A tolerance of 100 will force the vertex to snap directly to the division points.



A common use of the Split Polygon tool is to divide a face in half. This is done with a tolerance of 100.



However, the face can be split anyway you want as long as the last vertex ends up on an edge.



deformations

In the real world, some objects are hard and some are soft. The surfaces on the soft objects can be bent and folded into different shapes. This kind of surface deformation can be set up and animated in Maya.

Pushing and pulling the control points on a surface deforms its shape. Yet, to sculpt every surface point-by-point can be time consuming. Maya offers deformation tools that give 3D artists a higher level of control. A deformer can be applied to one or more objects and then a few control points or attributes can be edited to get bending and twisting.

Deformers can also be used as modeling tools because they are great for reshaping a surface. In the end, by deleting the construction history on the surfaces, the deformer disappears, leaving the new twisted surface.

The deformer attributes or control points can be animated to reshape an object over time. Deformers can also be bound to skeletons to help animate characters. Simulated deformations can then be used to create realistic draping and cloth effects.



Deforming Objects

Many objects in our 3D world are able to change their shape – a soft chair gives as someone sits in it, a rubber ball squashes and stretches as it hits the ground, human skin bends as the elbow rotates. To achieve these kinds of effects in Maya, surfaces have to be able to have their shape animated. This means animating the positions of control points instead of simply translating and rotating the object.

TYPES OF DEFORMATION

In Maya, there are a number of ways to change or deform the shape of an object. These deformers can be used to help you model surfaces or animate organic forms. While there are a set of tools in Maya called *deformers*, there are other tools that change the shape of objects. By becoming familiar with all of these techniques, you can best decide which one can be used in your work.

deforming objects

```
setAttr "spotLight1.rotate" -type double3 0  
2.56598  
Attr  
"spotLight1.translate" -type double3 0  
65.764707, 56.2441
```



A face with no deformations.



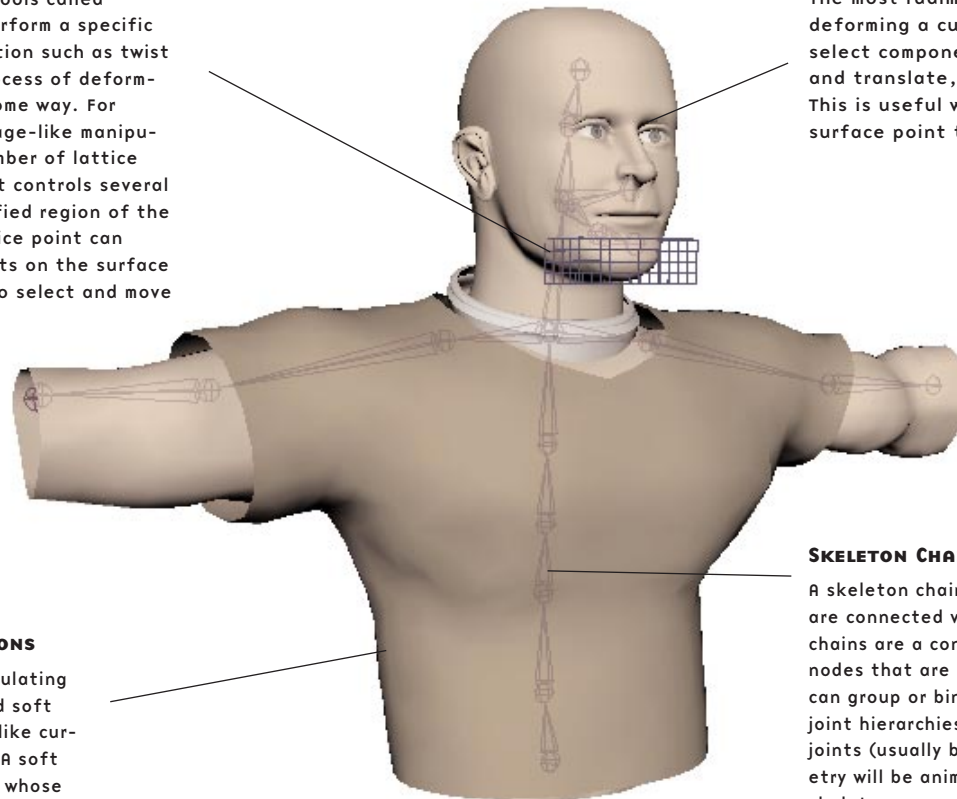
The same face after using surface deformation to reshape the nose, add a smile, round out the cheeks, widen the chin, and make folds for eyelids.

DEFORMERS

Maya has a category of tools called deformers that either perform a specific type of surface deformation such as twist or bend, or make the process of deforming a surface easier in some way. For example, a lattice is a cage-like manipulator made of a small number of lattice points. Each lattice point controls several control points in a specified region of the surface. Moving one lattice point can affect many control points on the surface that would be difficult to select and move individually.

SIMULATED DEFORMATIONS

Maya has features for simulating properties of clothing and soft dynamic moving materials like curtains, flames, and flags. A soft body is a geometry object whose control points are controlled by particles and dynamic fields such as turbulence and gravity.

**CV AND VERTEX EDITS**

The most rudimentary method of deforming a curve or geometry is to select component level control points and translate, rotate, or scale them. This is useful when you need to move a surface point to a specific location.

SKELETON CHAINS

A skeleton chain consists of joint nodes that are connected visually by bone icons. Skeleton chains are a continuous hierarchy of joint nodes that are parented to each other. You can group or bind geometry (skin) to these joint hierarchies. You can then animate the joints (usually by rotating them) and the geometry will be animated. Binding geometry to a skeleton causes the geometry to be deformed as the skeleton is animated. For example, you could rotate a neck joint and the geometry around the neck joint would rotate as well.



non-linear Deformers

```
setAttr "spotLight1.rotate" -type double3 0  
2.56598  
Attr  
"spotLight1.translate" -type double3 0  
65.764707, 56.444
```

Non-linear Deformers

Non-linear deformers control the deformation of the surface using simple deformation “handles.” These handles have easy-to-use attributes that can be changed to affect the characteristics of the deformation for each different non-linear deformer. These deformers are great for modeling objects into otherwise hard to form shapes and can also be used to animate the shape of the object to give it character. These deformers can be applied to polygons, NURBS, and Subdivision surfaces.

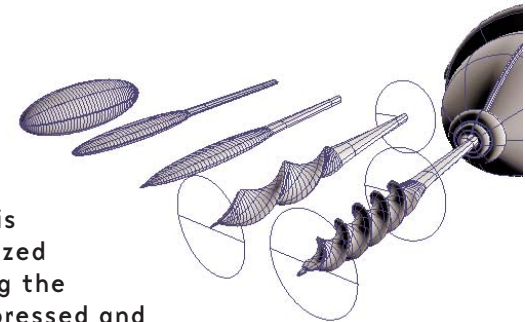
There are six non-linear deformers in Maya: **Bend**, **Flare**, **Sine**, **Squash**, **Twist**, and **Wave**. These deformers can be applied to an object by selecting the geometry, then choosing a deformer from **Deform > Create Nonlinear**.

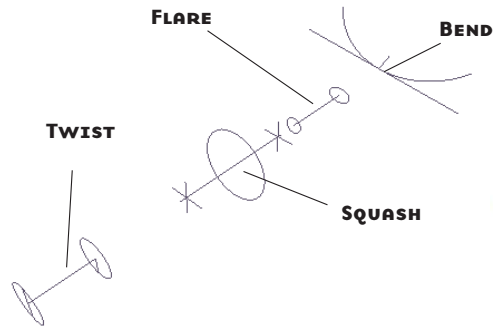
The term *non-linear* is used because the amount of deformation does not necessarily have to be the same across the entire surface. For example, if you have a model of a tree that you want to sway in the wind, you can make the trunk of the tree bend more at the top and less at the bottom. This ability to control deformation “dropoff” and regions of deformation is built directly into most of the non-linear deformers.

MODELING WITH NON-LINEAR DEFORMERS

The drill bit begins as a scaled NURBS primitive sphere with high detail. The Control Vertices (CVs) on the top “pole” of the sphere are selected and moved to elongate the drill bit. The shape is then flattened by scaling. Detail is added at the tip by manually adjusting CVs.

A **Twist** deformer is added to the overall shape. The geometry becomes pink when selected, indicating that the surface is connected to the deformer. The effect of the twisting is localized to influence only a specific region of the geometry by adjusting the deformer handle. As a result, the twist coils become more compressed and the finished shape is produced.





FLARE
The neck of the drill is a cylinder that is stretched and widened using a Flare deformer. This is an example where a deformer is used to model a shape.

TWIST
The drill bit is modeled by applying a Twist deformer to a sphere.

SQUASH
As the drill handle cranks, an animated Squash deformer can be used to bulge the body of the drill. This helps add character to the object.

BEND
The drill handle is shaped using a Bend deformer.

MANIPULATORS

Every non-linear deformer has a manipulator handle that lets you deform interactively. To access a handle, select it, click on the Show Manipulator Tool, then click on the deformer in the Input section of the Channel Box.

HIGH AND LOW BOUNDS

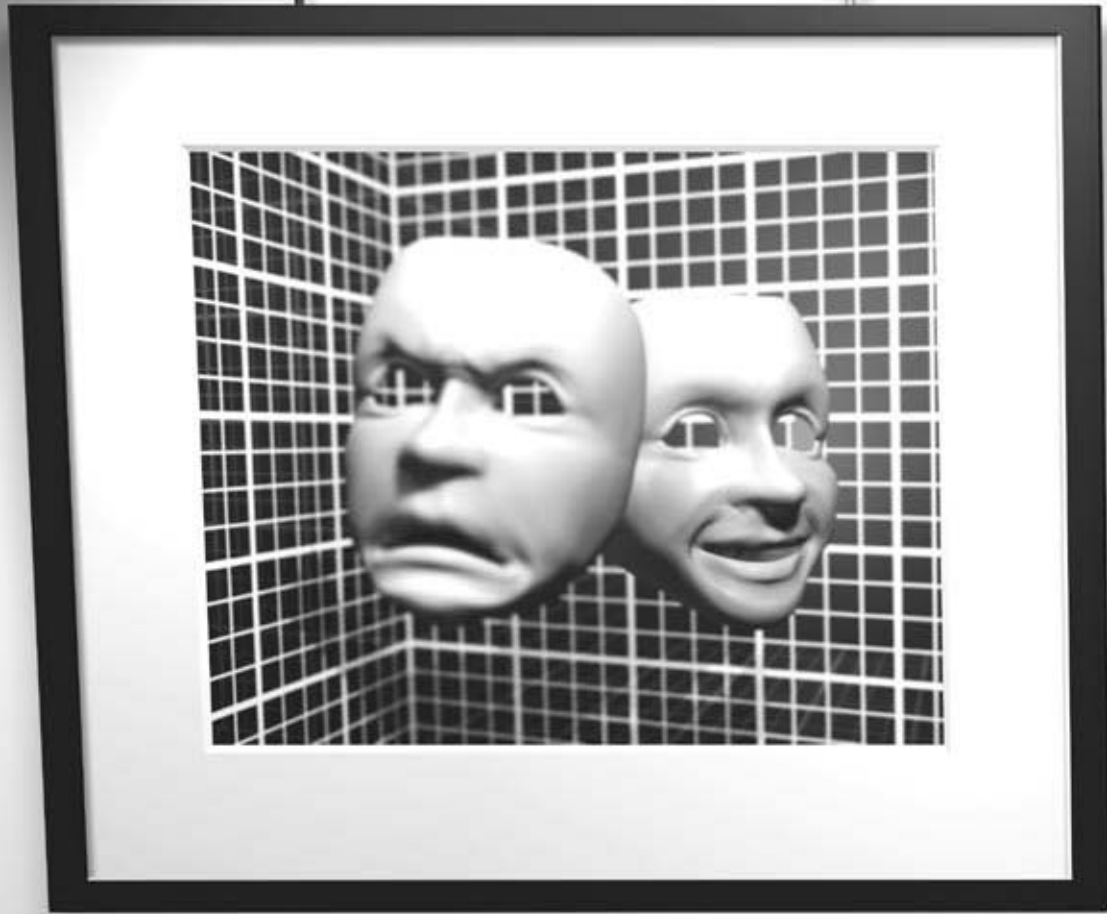
It is possible to influence the extent to which a deformer affects a surface. The High and Low Bounds let you define the deformed region of the surface. There are manipulators to help with this task.

Click-drag on the center of the circle to change the **High Bound**. This defines the end of the surface region that the deformer will influence.

Click-drag anywhere on the circle to change the **End Angle** of the twist.

Click-drag on the center of the circle to change the **Low Bound**. This defines the beginning of the surface region that the deformer will influence.

Click-drag anywhere on the circle to change the **Start Angle** of the twist.



| character | animation

One of the most challenging and rewarding forms of computer animation is character animation. Here, 3D artists combine the transformation of a digital skeleton with the deformation of a skinned surface, to set up a character that walks, talks, and moves around in 3D space.

Of course, a character doesn't have to be a human or an animal. Any object that is animated with expression and tries to speak to the audience through its actions is considered a character. In fact, the same techniques used to animate a dog might be used to animate a dancing bottle, a tiger or a tree.

Maya allows you to combine all the controls found on different parts of a character into one or more character sets. This makes it easier to pose characters and work with them in Maya's non-linear Trax animation system. These techniques help 3D artists set up characters that can be animated throughout a production with consistent and easy-to-use controls.



3D Characters

A 3D character is a digital actor. Whether your character is a tin can that bounces with personality, or a photorealistic human being, the animator will need to control it easily, and interactively. The specific requirements of the character's motion will dictate the complexity of the character's controls. Maya offers many tools for the creation of these digital performers.

A TYPICAL CHARACTER ANIMATION WORKFLOW

The development and animation of a 3D character involves a number of steps. Once you have a design, you must begin to build the character's model, lay down skeleton joints, and rig the skeleton so that it is capable of an appropriate range of motion. Character controls can also be set up to assist the animation process.

While it is possible to work in a linear fashion, starting with modeling and ending with rendering, most productions require some form of concurrent work to be done. An animator might need to begin laying down motion while the model is still being finished. At the same time, character deformations and texture maps may each be assigned to different parts of a team. For this reason, you may use your low-resolution character to begin animating and blocking out scenes while the higher resolution character is refined and set up for deformations and rendering.

3D Characters

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setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707 ; setAttr
```

CHARACTER DESIGN

In support of the story, the character is designed using sketches, storyboards, and in some cases, clay models. These visual aids give the 3D artist a clear understanding of the character and the character's range of motion and emotion.

MODELING

Using the sketches, a detailed model is built with an awareness of how it will be bound to the skeleton later.



BINDING SKELETON

The surfaces are bound to the skeleton and joint rotations tested. Deformers are used to enhance the final look.



SKELETON RIGGING

Using sketches or the model as a guide, joints are drawn and kinematics and character controls are set up.



ANIMATION

A fully rigged model that uses low-resolution surfaces parented to the skeleton can be used for initial animation studies.



INTEGRATION

The animation from the low-resolution character is applied to a fully rigged skeleton with bound surfaces and deformers.

RENDERING

The final character is rendered in its final setting. You might also render the character on its own, then use a compositing package to integrate it with the background.

A TYPICAL CHARACTER

The character's mechanics must be convincing to an audience and the skin and clothing must also move and bend properly. Maya includes a number of tools that help you manage the parts that make up a typical character. This process of preparing character controls is called *rigging* and is used to let the animator focus on the process of animating. A fully rigged character can be quite complex as it brings together skeleton joints, surfaces, deformers, expressions, Set Driven Key, constraints, IK, Blendshapes, etc.

SKELETON JOINTS

Joints are used to create a framework for a character's hierarchy. The rotation of the skeleton joints defines the motion of the character; you can use inverse kinematics for even more control.

CHARACTER CONTROLS

Using animation techniques such as Set Driven Key and expressions, you can set up attributes for controlling different parts of a character. For example, a hand joint could have attributes used to control the different finger joints.

CONSTRAINTS

It is possible to constrain the kinematic controls of a skeleton to objects in your scene or even simple locators. You can then animate the constraint weights to make a character pick something up or grab hold of a fixed object.

SELECTION HANDLES

Selection Handles give you quick access to parts of a character's hierarchy that are to be animated. This makes it easier to work with a character after it has been rigged up for animation.

FACIAL ANIMATION

To animate facial features, you can use deformers such as Blend Shape to create facial poses that can be used for talking and for showing emotion.

KINEMATICS

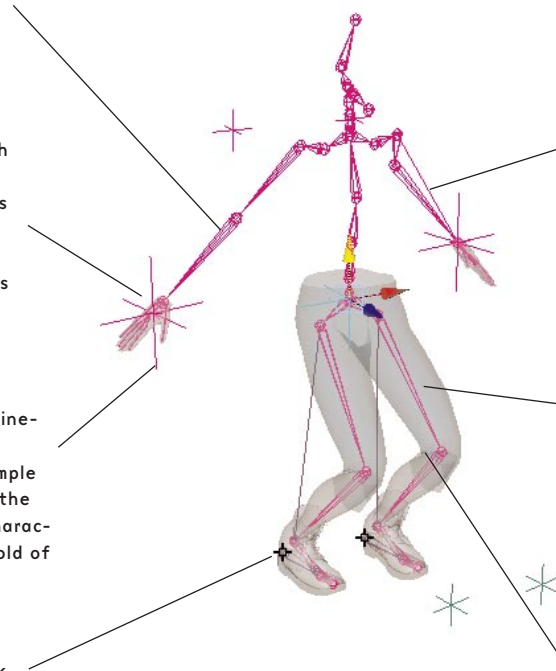
To control your skeleton joints, you can choose from forward or inverse kinematics. Forward Kinematics allows you to set the joint rotations directly. IK allows you to position IK Handles, which rotates the joints.

BOUND SURFACES

Surfaces of a character's skin and clothing can be either parented or bound to the skeleton joints to make them move together. Binding places points from a surface into clusters that are then associated with particular joints.

DEFORMERS

To help the surfaces bend realistically at joints, deformers such as flexors and influence objects can be used.





skeletons

```
setAttr "spotLight1.rotate" -type double3 0  
2.56598 ; setAttr  
"spotLight1.translate" -type double3 0  
65.764707 ; setAttr
```

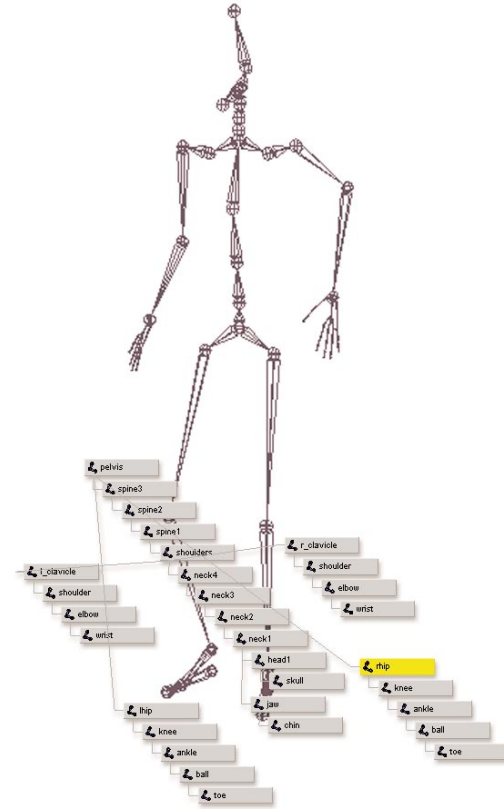
Skeletons

To give your characters a framework, skeleton joints can be drawn in 3D space to represent the bones of your character. These bones help you define and animate characters and are capable of a wide range of motion when combined with kinematic tools.

SKELETON CHAINS

Skeleton chains are hierarchies of nodes where the pivot point of each node is represented by a joint. The joint acts as a parent node for the hierarchy below. The joints are then connected using bones that help you visualize the hierarchical relationships in the 3D views. The resulting skeleton lets you build up a framework that can mimic the skeletal systems found in real humans and animals.

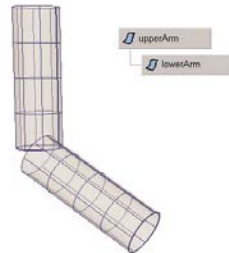
The most important thing to remember about skeleton joints is that they are part of a hierarchy and contain many of the properties of a typical Transform node. Therefore, you can move their pivot points, re-orient their local axes, and assign Selection Handles for easier control.



A skeleton is made up of joints. The joints are the Transform nodes of a typical character hierarchy.

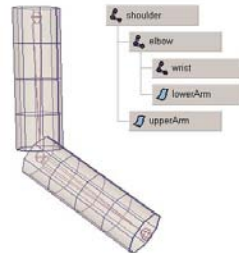
GROUPED OBJECTS

When computers were first used to represent crude characters, each segment of a limb was built separately, then parented to the next limb in a hierarchical relationship. The pivot point of each limb object represented its joint. The rotation of the limbs defined the motion.



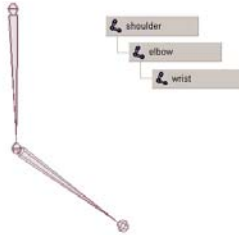
PARENTED OBJECTS

For renderable limbs, you can parent surfaces into the skeleton hierarchy. The skeleton gives you control. This technique is fast and is good for non-deforming surfaces such as armor or the limbs of a robot. This method is also used for low-resolution characters where speed is paramount.



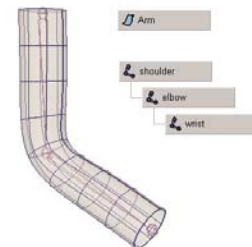
JOINTS

To help animators organize body parts, skeletons are used to define the limb hierarchy. Joints represent the rotational pivot points and bones represent how joints are connected. Rotating the joints defines the motion, but joints and bones don't render.



DEFORMING OBJECTS

Realistic characters have joints that bend. To create a surface that deforms with the skeleton, you can skin or bind a single surface or a patch network to the skeleton. This results in CV sets that can be weighted for smooth bending of the joints.



DRAWING SKELETONS

The **Joint** tool is used to draw skeletons. Each click adds a new joint to the scene. Bones are drawn between each joint to help you visualize the hierarchy.

As you draw, you can click on the Up arrow to go to a joint higher up in the hierarchy. As you continue drawing, the new joints branch off from this joint.

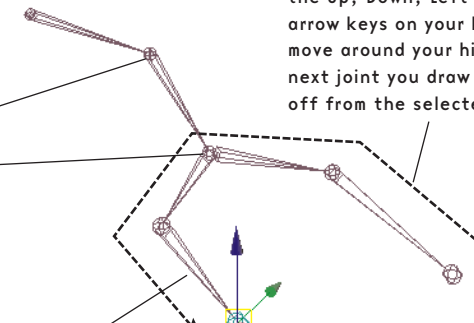
When a joint branches off, it appears as if you can work with the two bones independently. When you select the bones connected to the branching joint, you select a single joint which controls all the connected bones.

PICK-WALKING

As you draw joints, you can press the Up, Down, Left or Right arrow keys on your keyboard to move around your hierarchy. The next joint you draw will branch off from the selected node.

JOINTS

The joints are drawn as small circles that represent the axes of the joint.

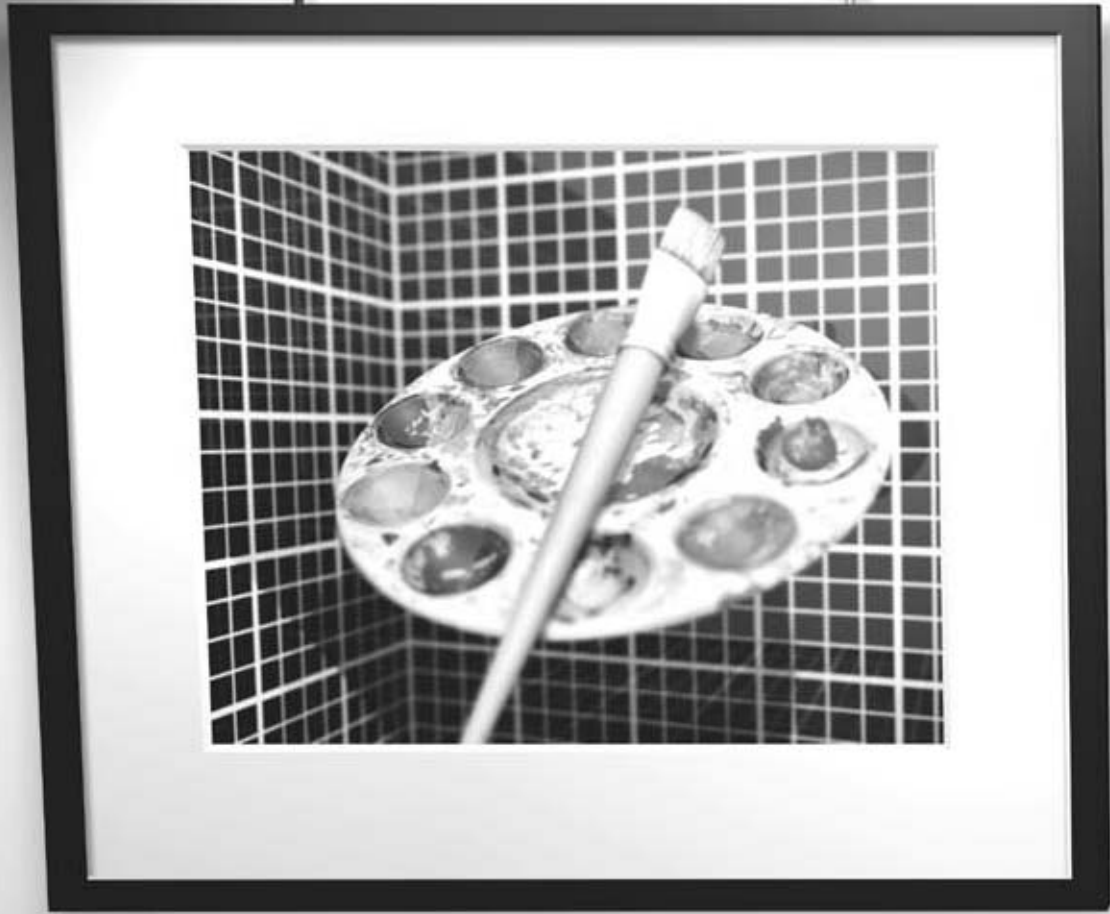


INSERT KEY

As you draw joints, press the **Insert** key to edit the joint position. Press **Insert** again to continue drawing. You can also use the Middle mouse button to reposition joints while drawing.

BONES

Between each joint is a bone which is drawn like a cone. This cone always points down the skeleton chain to the next joint in the hierarchy.



|materials |and |textures

While geometry describes the shape of an object, its material describes how its surface will appear when rendered. In the real world, when light hits a surface it reacts to the surface qualities. Some of the light is absorbed and some is reflected. A shiny object reflects light directly while a matte object diffuses the light. While reflected light does not actually illuminate other surfaces in Maya, materials and textures can be set up to simulate the real-world reaction of surfaces to light.

To create realistic images, material qualities such as color, specular, reflectivity, transparency, and surface detail must all be set. Maya uses special connected nodes called *Shading Networks* to set up the material qualities of your surfaces.

Textures let 3D artists create more complex looks for their surfaces. A texture can be a set of procedures set up in Maya or a bitmap image created outside Maya. In either case, realistic surfaces are created by combining geometry with well-designed textures.


```

setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
0.5 1.6470 1 ; setAttr

```



Shading Your Models

While geometry defines the shape of a model, shading defines how the model's surfaces react to light and details such as color, transparency, and texture. Maya uses Shading group nodes to tell the renderer which materials, textures, and lights will affect the final look of a surface. Shading networks are made up of nodes that define the final look of a rendered surface. Learning the proper role of each of these nodes will ensure that you build shading networks that render successfully.

BASIC SHADING

Shading shows you how the surface appears when illuminated. As light hits a surface, it defines a gradation from light to dark that makes the surface's 3D qualities apparent.



TRANSPARENCY

It is possible to see through transparent areas such as the glass on this jar, while opaque areas such as the label, cap, and paint remain solid. Transparent surfaces such as glass can also bend light. This is called refraction and can be achieved in Maya using Raytracing.

SURFACE RELIEF

Surface relief, such as bumps and scratches, helps add a realistic look to a surface. This effect can be achieved with special textures called *bump* and *displacement* maps.

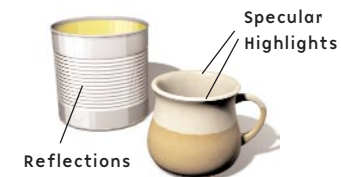


MATERIAL QUALITIES

Before actually looking at a more complex shading network, it is useful to consider the various material qualities that you will be trying to achieve. A basic understanding of how an object is shaded can be translated into attributes on shading network nodes in Maya.

HIGHLIGHTS AND REFLECTIONS

As a surface becomes shinier, it begins to show highlights and reflections. Specular highlights show the hotspots where the light sources are reflected, while reflections simulate light bounced from surrounding objects.



THE ANATOMY OF A SHADING NETWORK

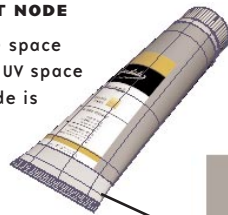
Shading networks are built as nodes that control specific aspects of the shading effect. These networks define how various color and texture nodes work with associated lights and surfaces. The placement of textures on surfaces is also controlled by nodes within the network.

There are several ways to view shading networks in Maya. The Hypershade window lets you easily connect nodes and view the connected attributes. You can also double-click on any node to open the Attribute Editor. Along the way, you can zoom in and out in the Hypershade to get the complete picture. You can also view shading networks in the Hypergraph window but this view does not give you swatch images.



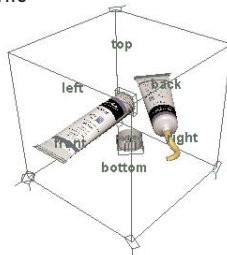
2D TEXTURE PLACEMENT NODE

A texture is mapped in 2D space when it is mapped to the UV space of the geometry. This node is used to define the texture's positioning and orientation within the UV space.



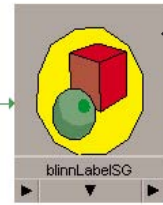
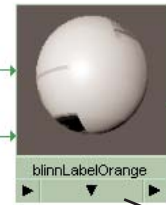
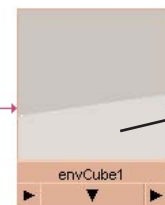
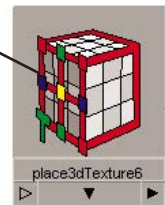
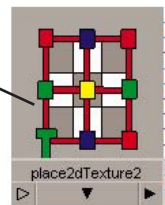
3D TEXTURE PLACEMENT NODE

This node lets you define a position in 3D space for your texture and makes it easier to texture multiple surfaces as if they were one. The icon in the modeling views can be used to interactively establish the texture's position in world space.



FILE TEXTURE NODE

File textures are bitmap images imported into Maya that can be used for texture mapping attributes such as color, bump, or transparency.



SHADING GROUP

This node is the root of the shading network. It sends information about materials and textures, lighting, and geometry to the renderer. In most cases, you will not have to work directly with the Shading group node because the Material node is where you will make most of your texture connections.

MATERIAL NODE

Material nodes define how the surfaces will react to light. The term *shader* is often used to describe the role played by the Material node. In general, this node will be the focus of your work as you build up all of your shading networks.





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setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
05.76470 ; setAttr
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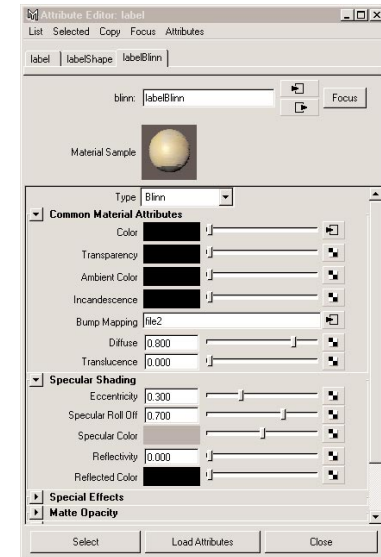
Surface Materials

Materials in the real world react to light by absorbing or reflecting it. Polished surfaces are shiny because they reflect light with strong highlights, while rough surfaces have a softer look because they disperse light. A Material node is a mathematical shading model that simulates a natural reaction to light.

The Material node contains a number of attributes that let you control how surfaces are shaded. Maya includes several material types, such as Phong, Blinn, and Lambert, that each define a different shading model. The Material node acts as a focal point for shading and texturing information. It is then fed into the Shading group node where it is combined with information about lights and the geometry to be rendered.

MATERIAL QUALITIES

The behavior of light when it strikes a surface in real life is quite complex. Surface imperfections can distort the angle at which light rays are reflected causing them to scatter and can also cause some light to become trapped, or absorbed. This type of scattered reflected light appears soft and even and is known as diffuse light. Very smooth surfaces have little or no surface imperfections so light is not absorbed and reflected light is more coherent or focused. When this light reaches our eyes, we see bright specular highlights. These real world behaviors are simulated in Maya with the Diffuse and Specular attributes.



The Material nodes have attributes in two main sections. **Common Material Attributes** are found on most Material nodes while the **Specular Shading Attributes** change, depending on the chosen material type.

MATERIAL TYPES

Several different material types offer you distinct shading characteristics. The main difference between them is how they handle specular highlights when rendered.

In the illustrations below, six of the most commonly used material types are compared. Texture maps on various attributes such as color, bump, and specularity will also have an impact on the appearance of the material.

LAMBERT

This material type is the most basic and does not include any attributes for specularity. This makes it perfect for matte surfaces that do not reflect the surrounding environment. The Lambert material type can be transparent and will refract in a Raytrace rendering, but without any specularity, it won't reflect.



PHONG

This material adds a sharp specular highlight to the Lambert material. The size and intensity of the highlights are controlled by the **Cosine Power** attribute. This material can also have reflections from either an environment map or Raytraced reflections. The Phong material is good for plastics.



BLINN

Many artists use this material type exclusively because it offers high-quality specular highlights using attributes such as **Eccentricity** and **Specular Roll Off**. This material type can be edited to look like a Phong material, which has sharper highlights, in cases where you need better anti-aliasing of highlights during an animation. This material is good for glass and metals.



PHONGE

This material type adds a different kind of specular highlight to the Lambert. The PhongE material includes attributes such as **Roughness** that controls the softness of the highlight, **Whiteness** that controls its intensity, and **Highlight Size**.



ANISOTROPIC

This material type simulates surfaces which have micro-facet grooves and the specular highlight tends to be perpendicular to the direction of the grooves. Materials such as hair, satin, and CDs all have anisotropic highlights.



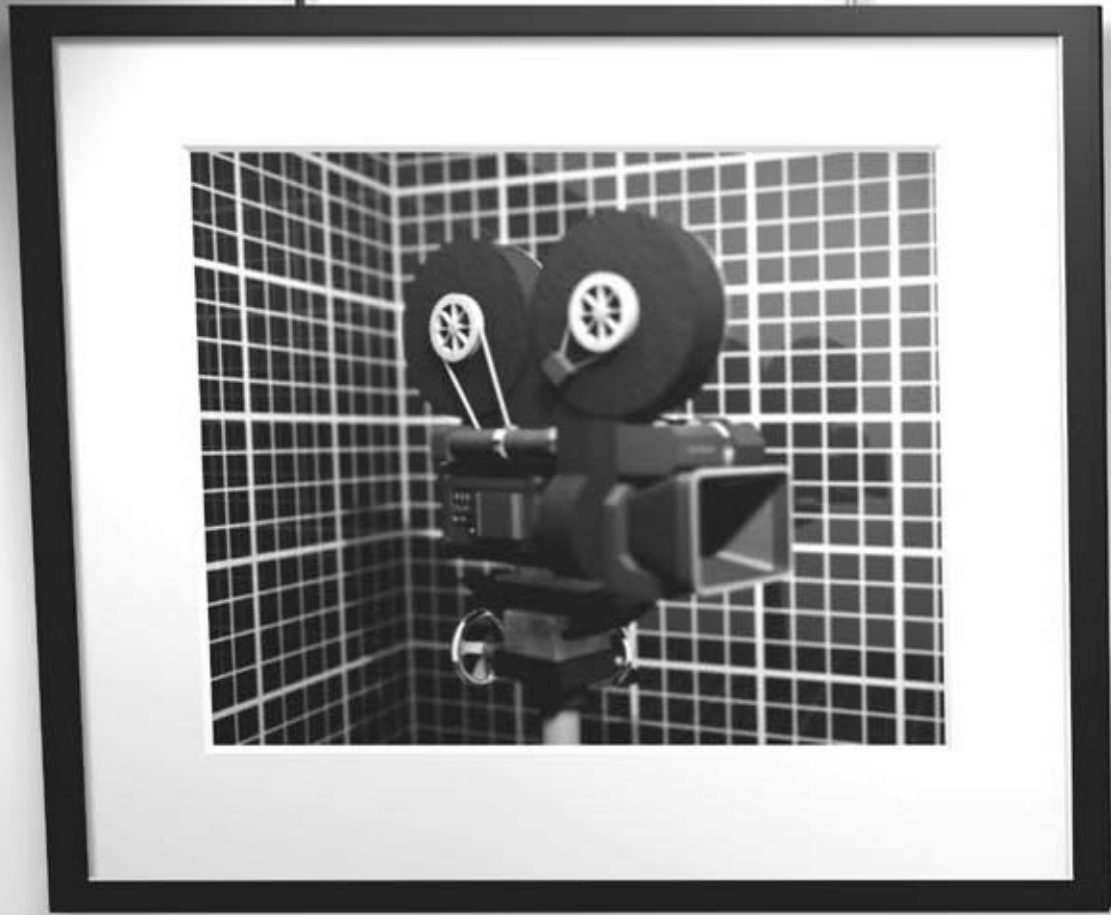
SHADING MAP

This material type allows you to create custom shading on surfaces. A ramp texture controls the positioning and color of the shading and highlights on the surface. If you want to emphasize the dark areas, simply darken the lower end of the ramp.



Ramp texture





|digital |cinematography

When preparing a digital scene, lights and cameras play a very important role. Both lights and cameras make it possible to view objects, and see them in a realistic context. Artistically, they both allow 3D artists to control the look of their animation with the same creative control as a live-action cinematographer.

In some ways, the most difficult aspect of using lights and cameras in Maya is that the possibilities are endless. It is very easy to fly a camera around without a clear sense of purpose or add too many lights to a scene. The question is whether or not the creative decisions support the story being told. Therefore, it is a good idea to consider how live-action movies make use of camera moves and lighting.

Another challenge for 3D artists is to integrate CG elements and live action footage. They must take lighting and camera properties from the real-world and mimic them in a scene so the audience does not have any idea the CG elements are even there.



How Lights Work

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setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707, setAttr
```

How Lights Work

Light affects the way in which we see the world around us. Light defines the shape and form of objects and spaces, while at the same time, it works at an emotional level by setting mood and atmosphere. Learning to control light is an important 3D skill.

Cinematographers use light to illuminate the objects in the scene while supporting the scene's emotional context. The quality of the light in a digital shot is equally important, although the rules are different.

SPOT LIGHT ATTRIBUTES

The spotlight's Shape node contains attributes that control how the light will illuminate the scene. Since the spotlight contains the most attributes, it is used as the example here. The other light types contain a subset of the Spot Light Attributes.

Hotspot

The point where the light is most intense is referred to as the hotspot. You also know it as a *specular highlight*. The look of the highlight is a result of the intensity of the light and the shading qualities of the surface's Material node.

Color

You can set RGB values for the light being emitted. This will have an influence on the color of your scene.

Dropoff

This attribute determines how much the light intensity diminishes as it gets to the outer edge of the light. This puts more emphasis on the light's hotspot.

Intensity

This attribute determines how much light is emitted from the light source. As you increase the **Decay** and **Dropoff** values, you need a more intense light.

Decay

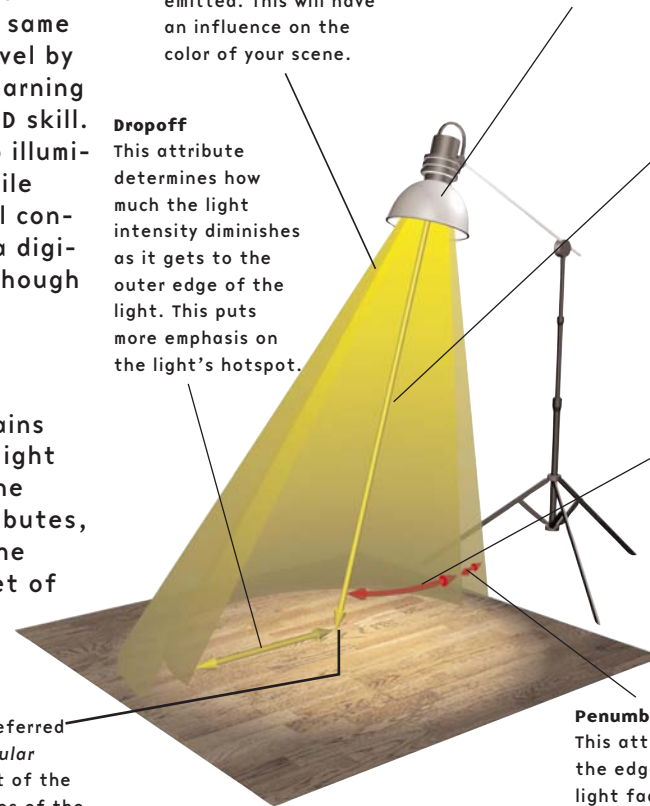
This attribute determines how much the light intensity diminishes as the light gets further from its source. Therefore, if you choose to use **Decay**, you need to increase the **Intensity**.

Cone Angle

This attribute determines the width of the spotlight's cone of influence. The areas outside the cone are not illuminated.

Penumbra Angle

This attribute creates an area at the edge of the spotlight where the light fades. A larger value here creates a soft look for the light.



REAL WORLD VS. DIGITAL CINEMATOGRAPHY

In the real world, light bounces. Light starts from a light source such as the sun or a lamp and is either bounced or absorbed by all surfaces. An object appears red because the green and blue light is absorbed while the red light is reflected. A cinematographer sets up lights, then measures the light levels, which include both direct and indirect light. This information is used to adjust the exposure settings of the camera.

In Maya, surfaces are illuminated directly by lights. There is no bounced light coming from other surfaces. This is because CG lighting doesn't bounce. Here, film isn't exposed to light and camera controls don't need to be adjusted. Light levels are, therefore, controlled using the intensity settings of the lights themselves.

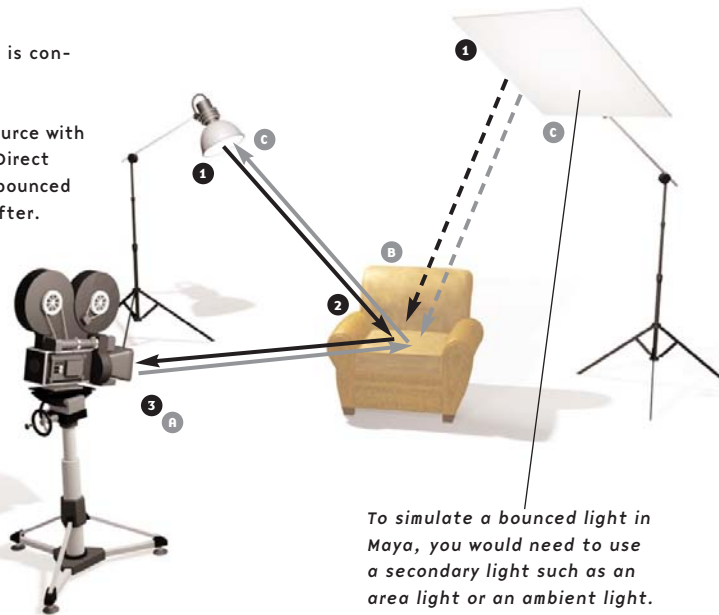
IN THE REAL WORLD

The film's exposure to light is controlled by the camera.

1 Light is emitted from a source with a controllable intensity. Direct light is hard, while light bounced from other surfaces is softer.

2 Light levels are measured using a light meter to determine the proper exposure settings for the camera.

3 Camera controls such as F-stop, shutter angle, exposure time, and film speed are set to control how much light is exposed to the film.



ON THE COMPUTER

The intensity of the lighting is controlled by the lights.

A From the camera's point of view, the renderer samples a point on a surface.

B From the surface's shading group, a list of associated lights is used to determine which lights should be factored in.

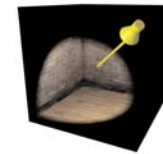
C The light's attributes, such as intensity, color, and decay, are used to calculate the illumination on the surface.

LIGHT TYPES

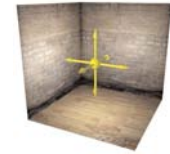
Maya has several light types, each of which illuminates a scene differently. A typical scene combines a number of different light types. You can switch between light types in the Attribute Editor.



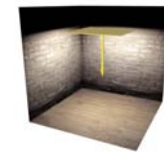
DIRECTIONAL



SPOT



POINT



AREA



AMBIENT

Casting Shadows

```
setAttr "spotLight1.rotate" -type double3 0  
2.56598 ; setAttr  
"spotLight1.translate" -type double3 0  
65.764707, setAttr
```



Casting Shadows

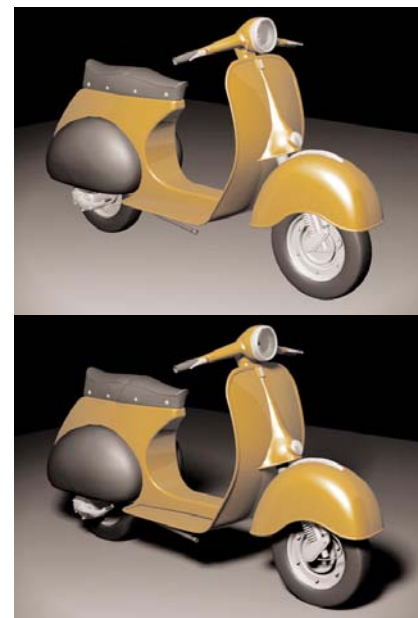
One of the most dramatic aspects of lighting is in the area where there is no light. Shadows add drama to your scene while helping to anchor characters and props to the ground. If your character leaps into the air, you know what is happening because the shadow and the character no longer touch each other.

In Maya, there are many factors that affect the look and quality of your shadows. You can choose from Depth Map and Raytraced shadows which offer different levels of quality and speed. Sometimes light attributes, such as Cone Angle will affect your shadows and must be taken into account. The more you know about how shadows are cast, the easier it will be to adjust the appropriate attributes.

DEPTH MAP SHADOWS

Depth Map shadows are the more efficient of the two shadow types. A Depth Map shadow can be created by setting **Use Depth Map Shadows** to **On** in the light's Attribute Editor.

Depth Map shadows work by recording the Z-depth information from the light's point of view, then using this information to evaluate whether or not a point in your scene is in shadow. The diagram below shows how a spotlight evaluates Depth Map information to generate shadows. You can see that the Depth Map is generated from the light's point of view.

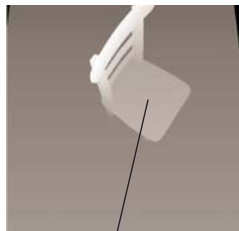


WITH AND WITHOUT SHADOWS

Here are two shots of a scene. The first does not use shadows and the second one does. You can see how the scooter in the second image is much more grounded, and it is easier to read the scene's depth. While shadows do require extra work when you set up a scene, they are well worth the effort.

STEP 1

When a rendering starts, a Depth Map is created from the light's point of view that measures how far the various objects are from the light. White is used to show surface points closest to the light, while the various shades of gray show a greater distance from the light.



Stored Depth Map Value

STEP 2

When a point on a surface is being shaded during the rendering process, the distance is measured between the point and the light source.

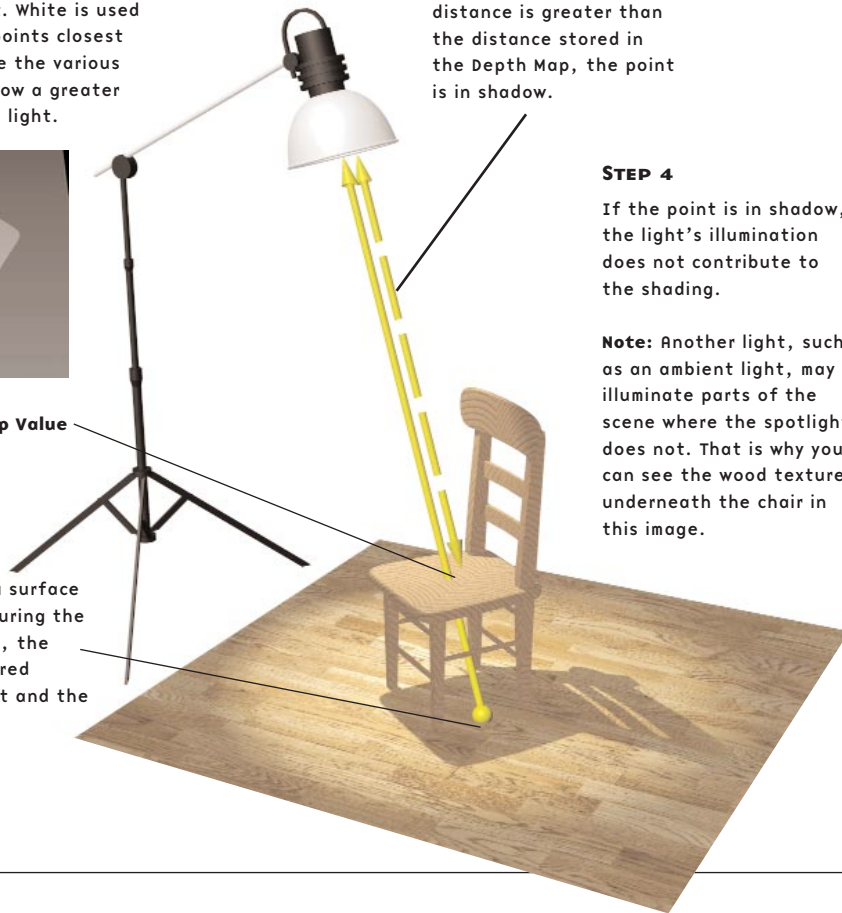
STEP 3

This measurement is then compared to the depth information stored in the Depth Map. If the point's distance is greater than the distance stored in the Depth Map, the point is in shadow.

STEP 4

If the point is in shadow, the light's illumination does not contribute to the shading.

Note: Another light, such as an ambient light, may illuminate parts of the scene where the spotlight does not. That is why you can see the wood texture underneath the chair in this image.



RAYTRACED SHADOWS

To calculate Raytraced shadows, Maya sends a ray from the camera and when this ray hits a surface, it spawns another ray toward the light. This shadow ray reports whether or not it hits any shadow-casting objects on its way to the light. If it does hit a shadow-casting object, then the original surface is in shadow.

Raytraced shadows have the disadvantage of being slower to render than Depth Map shadows. However, depending on the look you are interested in, there are several reasons why you would use Raytraced shadows in your scene, these include transparent shadows, colored transparent shadows, and shadow attenuation.

If you want Raytraced shadows, but not reflections and refractions, then set **Reflections** and **Refractions** to 0 in the **Render Quality** section of the **Render Settings**.





| rendering

A 3D artist's ultimate goal is to create a sequence of images that can be synchronized with sound and played back as a movie. The creation of these images is the job of the renderer where surfaces, materials, lights, and motion are all taken into account and turned into bitmap images.

The art of rendering involves finding a balance between the visual complexity needed to tell a story and the rendering speed that determines how many frames can be rendered in a given time. Simple models render quickly and complex models take longer.

Therefore, the render artist brings together all the parts created throughout the animation pipeline and ensures that they render with high quality as fast as possible. This means exploring the interaction of surfaces, lights, and materials and making sure that the pixels look right in their final form.

```
setAttr "spotLight1.rotate" -type double3 0
2.56598 ; setAttr
"spotLight1.translate" -type double3 0
65.764707; setAttr
```



Rendering Scenes

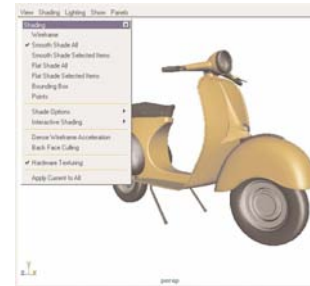
Rendering is where all of the work in setting up models, textures, lights, cameras, and effects comes together into a final sequence of images. In very simple terms, rendering is the creation of pixels that are given different colors in order to form a complete image. A render involves a large number of complex calculations that can keep your computer busy for quite a while. The key at this stage in the animation process is to find a way of getting the best image quality and the fastest render times so that you can meet your deadlines.

Before exploring the specific details of rendering animation sequences, it is important to realize that there are two different methods in Maya: software and hardware rendering. The software rendering process is considerably more complex and requires a great deal more knowledge and understanding to get the best results. The renderer is where all of your scene data and settings are handed off to the software and render calculations are performed that result in final bitmap images. To give you some insight into what Maya actually does with your scene data during this process, an overview of the software render process itself is shown on the next page.

HARDWARE RENDERING

Hardware shading, texturing, and lighting use the computer's graphics hardware to display objects on the screen. You can use the Hardware Render Buffer to take snapshots of each frame and save them to disk.

Because hardware is designed to perform only specific tasks, its rendering capabilities have the advantage of being very fast, but lack the sophistication of features such as shadows, reflections, and post-process effects. Hardware rendering is used primarily to render hardware-type particle effects which are later enhanced in a compositing application.



HARDWARE SHADING

You can display hardware shading, texturing, and lighting in any view panel using the the panel's **Shading** menu.



HARDWARE RENDER BUFFER

The **Hardware Render Buffer** is a special window used for out-putting hardware-rendered images.

SOFTWARE RENDERING

The software renderer uses complex algorithms to combine elements such as geometry, cameras, and textures, with the physics of light to create final bitmap images. Because some aspects of light's true behavior would be prohibitively slow to calculate, most renderers let you employ shortcuts such as ambient lights in place of global illumination to make sure that rendering times support the production cycle.

Software rendering has the advantage of being more flexible than hardware rendering. Software companies can add functionality by changing algorithms in the code without being restricted by the computer's hardware. Therefore while software rendering is not as fast as hardware rendering, the added functionality lets you achieve more sophisticated results.

RENDER VIEW

Maya's Render View window allows you to launch a software render and watch the results as the file is being rendered. It can be used for everything from a quick test on a low quality render to a final production render. However, because it only renders the current frame, it is not used to render animation.

While rendering in the Render View window, Maya itself is the renderer; there is no intermediate file or separate rendering application as is the case with other renderers. Consequently, Maya does not allow you to make changes to the open scene's data as it is being rendered.

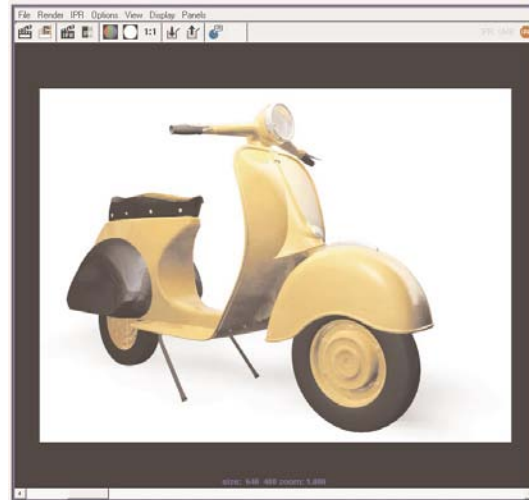


IMAGE ZOOM

By default, images are automatically resized to fit into the Render View window. This means that you may be seeing your image at a zoom value other than 1.0. This scaled image will appear jagged in most cases, making it look like it has anti-aliasing problems. Press the 1:1 button to view the image at its true size. If you still see jagged edges, adjust the anti-aliasing settings in Render Settings.

BATCH RENDERING

To software render your animation, you will use the Batch renderer, which can be launched inside the Maya interface or from a command line. When you start a Batch render from within an interactive session, a scene file is saved and another copy of Maya (with no user interface) is launched to do the render. This means that you can keep working on your scene in Maya while the render is in progress. For maximum speed when rendering your final animation, you should render from a command line (for example UNIX shell, DOS command prompt window) with no interactive Maya session running.

The Render Settings attributes let you specify the camera, anti-aliasing quality, resolution, etc. for the Batch render. If rendering from a command line, there are many flags which can be set to override any Render Settings saved in a file. This can be very useful and efficient in cases where the scene file takes a long time to open.



Render Output

```
setAttr "spotLight1.rotate" -type double 0
2.56598 ; setAttr
"spotLight1.translate" -type double 0
65.764707 ; setAttr
```

Render Output

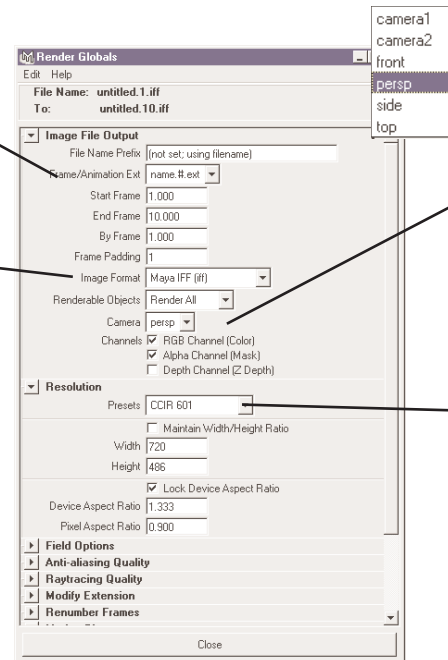
Based on your post-production requirements, your final rendered image or sequence of images will need to suit the medium you are outputting it to. These image properties, such as size, format, and frame padding, are set from the Render Settings Window.

IMAGE FORMATS

The Image Formats pop-up list allows you to specify the format you need your rendered frames to be in. Maya's online documentation has a detailed description of how each of these formats handles image, mask, and depth information. The Maya IFF file format is also documented. Some formats are only available on some platforms.

- Alias PIX (.als)
- AVI (.avi)
- Cineon (.cin)
- EPS (.eps)
- GIF (.gif)
- JPEG (.jpg)
- Maya IFF (.iff)
- Maya16 IFF (.iff)
- Quantel (.yuv)
- RLA (.rla)
- SGI (.sgi)
- SGI16 (.sgi)
- SoftImage (.pic)
- Targa (.tga)
- Tiff (.tif)
- Tiff16 (.tif)
- Windows Bitmap (.bmp)

- name.ext.#
- name
- name.ext
- name.#.ext
- name.ext.#
- name.#



RENDERABLE CAMERA

The pop-up Camera list allows you to choose which camera will be used in the Batch render. It is possible to render from more than one camera in a Batch render. This Render Setting does not affect which camera is used while rendering in the Render View window within Maya.

RENDER RESOLUTION

The Render Resolution refers to the dimensions of a rendered frame in pixels. Maya's list of presets allows you to quickly select a resolution from a list of those commonly used in the industry.

- Custom
- 320x240
- 640x480
- 1k Square
- 2k Square
- 3k Square
- 4k Square
- CCIR 601
- CCIR PAL
- DigitalVideo
- Full 1024
- Full 1280
- HD 720
- HD 1080
- NTSC 4d
- PAL 768
- PAL 780
- Quantel PAL (.qt)
- Quantel NTSC (.qt)
- Screen
- Targa 486 (.tga)
- Targa NTSC (.tga)
- Targa PAL (.tga)

RENDERING ANIMATION

An image file name consists of three components when rendering an animation: file name, frame number extension, and file format extension. (A combination of these three components is referred to as the *file name syntax*.)

The file name is the base name for all images in the animation sequence. The frame number extension represents the frame in the Time Slider in which the image is rendered. The file format extension indicates your chosen file format. You can see these combined as a preview at the top of the Render Settings window.

You need to tell Maya what frames to render when rendering an animation. After a Start Frame and an End Frame are specified, Maya renders all the frames in between by default. However, if you want to render every 10th frame for test purposes, you can set the By Frame attribute to 10. In this case, Maya only renders every 10th frame, beginning with the Start Frame number.

IMAGE FORMATS

Maya's Render Settings lets you render your images in the specific format that you need for your production pipeline. The default image format is Maya's IFF, but you can choose from a list of many standards used in computer graphics such as TIFF, GIF, JPEG, Quantel, etc. Most of the formats are 8 bits per channel, but Maya also renders 10-bit Cineon and several 16-bit formats which are commonly used for film. Human eyes can perceive more colors than 8-bits can represent, so high-resolution formats such as film sometimes require better color definition to look realistic.

Maya also lets you render directly to AVI or QuickTime movies. While this may be convenient, you might also consider rendering in one of the other formats that creates separate images so that you have more flexibility. An application such as Maya Fusion allows you to create a movie from the images after any adjustments have been made.

CHANNELS

The color channels of a rendered image are made up of red, green, and blue (RGB). A mask channel (or alpha channel) stores information about the coverage and opacity of the objects in your scene. This channel allows you to work with your rendered images in a compositing software.

A depth channel records the distance from the camera to the objects in the scene. This is often called Z-depth and you can look at it using the Z-key in F-check.

Maya can render an image file that contains RGB color information, a mask channel, a depth channel or any combination of the three. The flags in the Render Settings window let you choose what channels will be rendered. Some image formats do not support embedded mask or depth channels; in these cases, Maya generates a separate mask or depth file and puts it in the mask or depth sub-directory of your current project.



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